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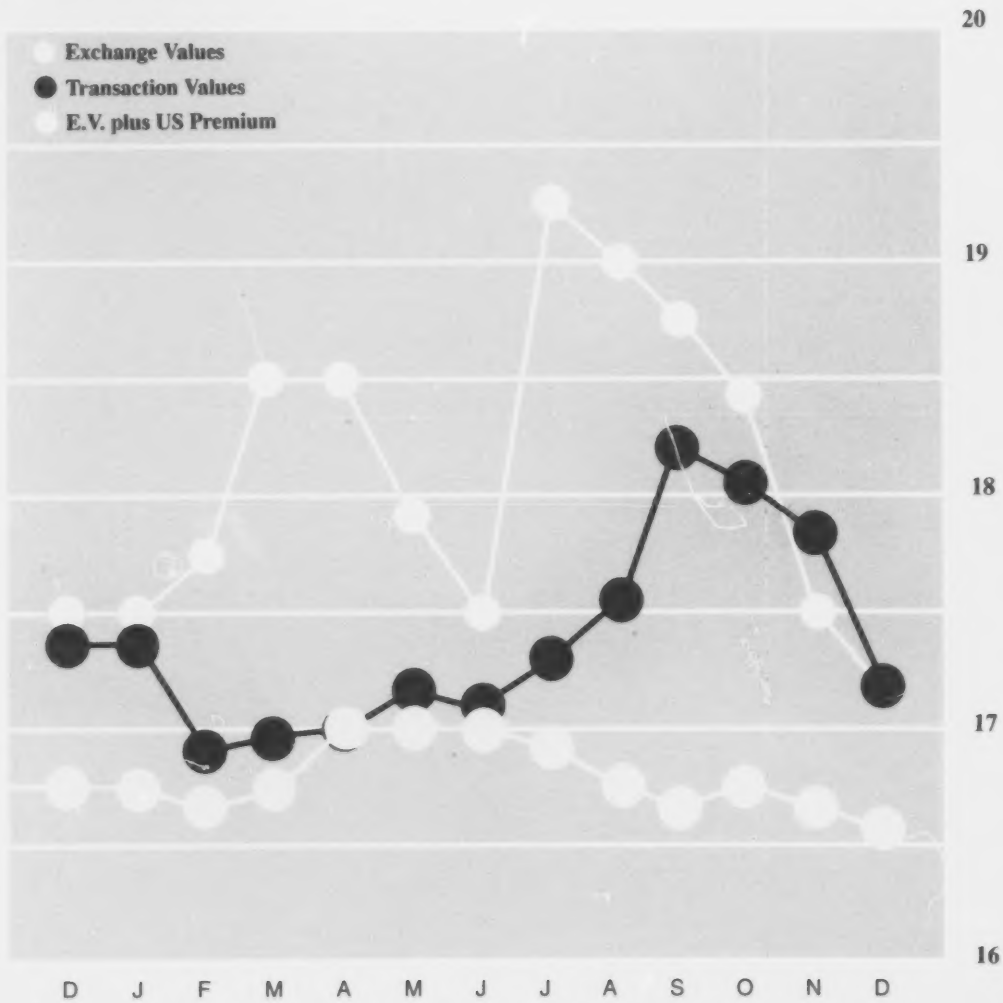
Annual Review

1987



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1987 ANNUAL REVIEW

Special Report — Spring 1988

R. GENE CLARK, EDITOR — CHARLES B. LEWIS, ASSISTANT EDITOR

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To Our Readers

* * *

Nuexco is pleased to present our 1987 Annual Review. As in the past, this Annual Review is the product of efforts from many Nuexco professionals. The editors appreciate the contributions and trust our readers will find the Annual Review informative and useful.

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NATURAL URANIUM SUPPLY, DEMAND, AND PRICES

Overview

The spot market for uranium in 1987 was characterized by a high degree of discretionary demand and complications surrounding the issue of national origin. World U_3O_8 prices for spot and near-term delivery (as represented by the Exchange Value) remained stable at or slightly below the $17.00 level for the entire year, although relatively large fluctuations occurred in the price premium for US-origin uranium. That premium, which Nuexco began publishing in late 1986, was influenced by events in the political and judicial arenas and by the willingness of many US utilities to pay higher prices for US-origin material. The two-tiered market for uranium had important implications for utility procurement strategy in the USA, as well as for uranium producers worldwide. As of early 1988, the origin problem was still being discussed in the courts and in Congress, but resolution of most of the uncertainties was expected during 1988.

The general stability of the Exchange Value during 1987, as shown in Table 1, was primarily a function of the lack of uncovered demand worldwide. Most utilities were adequately covered by long-term supply contracts and inventories. A small number of European utilities did have spot requirements, and others made discretionary purchases. In the USA, the uncertainty over the potential restrictions on use or enrichment of non-US-origin uranium discouraged some US utilities from participation in that market. Aggressive selling by producers and intermediaries filled those sales opportunities that did arise, and the competition precluded any price increase.

Unlike the Exchange Value, the premium for US-origin uranium responded to political pressures over the course of the year. The following two events greatly influenced market participants' perceptions of the value of US-origin uranium:

1. Following the 1986 US District Court ruling in favor of the US producers in their lawsuit against the Department of Energy (DOE), the US Circuit Court of Appeals reviewed the case and, in July 1987, upheld Judge Carrigan's earlier ruling. (For a detailed description of the lawsuit, see the *United States* section of this report.) Nuexco began publishing a premium for US-origin shortly after the Carrigan ruling; it rose from $0.65 per pound U_3O_8 in late 1986 to $1.50 in April and May 1987. The Premium had begun to fall in the early summer of 1987, but jumped to $2.50 per pound U_3O_8 immediately following the Appeals Court ruling.

2. In October 1987, the Reagan Administration announced that it had concluded a Free Trade Agreement (FTA) with the Canadian government; President Reagan and Prime Minister Mulroney signed it on January 2, 1988. The FTA is now awaiting implementation by the Canadian Parliament and the US Congress. The FTA would eliminate the Canadian upgrading requirement that has generally prevented the export of Canadian U_3O_8 to the USA. Moreover, it would exempt Canadian uranium from the restrictions imposed by Judge Carrigan.

Supply, Demand and Prices

Table 1 lists the Exchange Value, the UF_6 Value and the supply and demand for natural uranium reported by Nuexco during 1987. World prices continued the stable trend evident throughout the previous year, fluctuating by less than five percent in dollar terms, and price movements for U_3O_8 generally corresponded with those for UF_6.

US utilities made up the largest share of demand, with about half of their requests specifying material, both U_3O_8 and UF_6, of US-origin. Those US utilities interested in non-US-origin uranium generally sought Canadian UF_6 for near-term use. European utilities, on the other hand, favored non-US-origin concentrates. About half of the material sold into Europe during the year originated in central and southern Africa, with the balance coming from Canada. One buyer in the Far East entered the market in the fourth quarter, but activity in that region remained quiet, as in recent years.

The particular requirements of buyers as regards form, origin, and delivery location frequently were met by intermediaries able to structure complex multi-party arrangements. Other producers used intermediaries to shield their identities from end-users. Few utilities entered the market to sell material in 1987. Utility liquidations were no longer a significant factor in the market in 1987.

The flat price trend was caused by the combination of large, low-cost producer inventories plus increased output by some producers, and sporadic, discretionary utility demand. Producers in both Canada and South Africa, the two largest producing countries outside the USA, had large

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MARKET DEVELOPMENTS

Table 1

1987 NATURAL URANIUM MARKET VALUES

Determined as of the Last Day of the Month	Published in Report Number	Exchange Value[1] (per lb. U_3O_8)	US Premium (per lb. U_3O_8)	UF_6 Value[2] (per kg U as UF_6)	US UF_6 Premium (per kg U as UF_6)	Uranium Supply (1,000 lbs. U_3O_8)	Uranium Demand (1,000 lbs. U_3O_8)	Supply/ Demand Ratio
January	222	$16.75	$0.85	$47.75	$2.50	3,845	2,143	1.8
February	223	$16.65	$1.00	$47.75	$2.50	3,445	2,310	1.5
March	224	$16.75	$1.50	$48.00	$3.50	3,495	1,800	1.9
April	225	$17.00	$1.50	$48.00	$3.00	4,495	575	7.8
May	226	$17.00	$0.90	$48.00	$2.25	4,080	1,375	3.0
June	227	$17.00	$0.60	$47.75	$1.75	3,680	1,000	3.7
July	228	$16.90	$2.50	$47.75	$6.50	2,830	2,485	1.1
August	229	$16.75	$2.35	$47.50	$6.00	3,730	2,025	1.8
September	230	$16.65	$2.10	$47.00	$4.25	6,435	1,725	3.7
October	231	$16.75	$1.65	$47.00	$3.10	5,735	1,985	2.9
November	232	$16.65	$0.85	$47.00	$2.25	6,845	1,275	5.4
December	233	$16.55	$0.65	$47.00	$2.00	4,750	2,395	2.0
Annual Average		$16.78	$1.37	$47.54	$3.30	4,447	1,758	3.0

[1]The *Exchange Value* is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the last day of the month indicated.

[2]The *UF_6 Value* is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.

stockpiles, and in the case of Canada, production increased during 1987. Because production costs in both countries are low, occasional spot market sales, even at the relatively low prices current in the market, were an attractive option.

Utility demand for non-US-origin material was moderate throughout the year, effectively preventing any upward price movement. Those utilities with actual needs tended to act cautiously, encouraging competition among sellers. Discretionary buyers, especially in Europe, frequently purchased quietly when presented with particularly attractive terms.

The US dollar continued to weaken against European currencies during 1987 (Table 2), although the decline was far less dramatic than during 1985 and 1986. Uranium prices appeared to be highly attractive to European buyers when expressed in the currencies of their respective countries. Nevertheless, little purchasing activity was attributed directly to exchange rate movements as there was not much expectation of a sudden recovery in the value of the US dollar.

The US-Origin Premium

In November 1986, Nuexco began publishing a premium for US-origin uranium. This Premium reflects Nuexco's judgment of the incremental value, over and above the Exchange Value, that is needed to obtain US-origin material when the buyer would accept only US-origin. Following the Carrigan ruling, it had become apparent that many utility buyers were willing to pay more for the security of holding US-origin uranium in the event that some restriction on the use or enrichment of non-US-origin uranium was adopted. This restriction could have taken the form of the total prohibition of enrichment of foreign uranium as mandated by the Carrigan ruling, if it were upheld through the appeal system, or it could have come about through legislation and applied to the use of non-US-origin uranium in the reactor. Regardless, many US utilities chose to increase their stocks of US-origin material as insurance against such potential restrictions.

Figure 1 shows the levels of the Nuexco US-Origin Premium from its inception and throughout 1987. The premium rose steadily from November 1986 through April

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Table 2

NUEXCO EXCHANGE VALUE AT QUARTERLY INTERVALS DURING 1987 EXPRESSED IN SELECTED CURRENCIES[1]

Country (currency)	Dec. 31, 1986	March 31, 1987	June 30, 1987	Sept. 30, 1987	Dec. 31, 1987	Percent Change Since Dec. 1986
Australia (dollar)	25.21	24.16	25.35	27.06	22.97	- 8.9
Belgium (comm. franc)	678.06	633.86	640.15	635.74	552.22	- 18.6
Canada (dollar)	23.16	22.22	22.53	21.83	21.55	- 7.0
EEC (ecu)	15.73	14.80	14.91	14.75	12.81	- 18.6
Finland (markka)	80.65	75.35	75.21	73.48	65.70	- 18.5
France (franc)	108.00	101.86	103.11	101.96	89.36	- 17.3
FRG (mark)	32.58	30.54	30.90	30.63	26.40	- 19.0
Italy (lira)	22,681	21,862	22,411	22,112	19,480	- 14.1
Japan (yen)	2,677	2,484	2,478	2,437	2,041	- 23.8
Netherlands (guilder)	36.85	34.57	34.82	34.48	29.71	- 19.4
South Africa (rand)	36.81	34.07	34.53	34.51	31.92	- 13.3
Spain (peseta)	2,219	2,157	2,415	2,026	1,801	- 18.8
Sweden (krona)	114.10	107.32	107.92	107.07	96.50	- 15.4
Switzerland (franc)	27.22	25.48	25.68	25.46	21.35	- 21.6
UK (pound)	11.40	10.58	10.56	10.22	8.91	- 21.8
US (dollar)	16.75	17.00	16.90	16.65	16.55	- 1.2

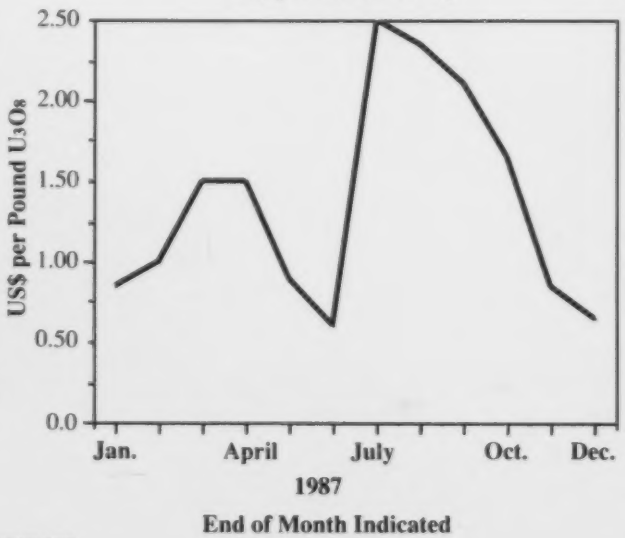
[1]Currency exchange rates from the *Wall Street Journal* of the date indicated.

1987, from $0.65 to $1.50. During the lengthy period following DOE's appeal, and prior to the Appeals Court's eventual decision, the Premium had begun to fall as buyers speculated the Carrigan ruling might be overturned. In July 1987, the Appeals Court upheld the original ruling, making enrichment restrictions appear far more likely, and the market responded by forcing up the Premium to $2.50 per pound U_3O_8 over the Exchange Value. DOE then petitioned the US Supreme Court to review the case, but delays in the appeal process again caused the Premium to decline. While some observers predicted that the Supreme Court would find no merit to the case and refuse to hear it, another external pressure emerged in the market.

The Reagan Administration announced on October 5, 1987 that it had concluded the Free Trade Agreement with Canada. The final text of the Agreement, released in December 1987, incorporated the provisions removing the Canadian "upgrading requirement," and exempted Canada from any restriction on the enrichment of foreign uranium enacted under Section 161(v) of the Atomic Energy Act. The language of Section 161(v) is the basis for the US producers' lawsuit against DOE.

Figure 1

THE PREMIUM FOR US-ORIGIN U_3O_8
(Relative to the Exchange Value, US$ per Pound U_3O_8)



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MARKET DEVELOPMENTS

Figure 2

ANALYSIS OF 1987 TRANSACTIONS REPORTED BY NUEXCO

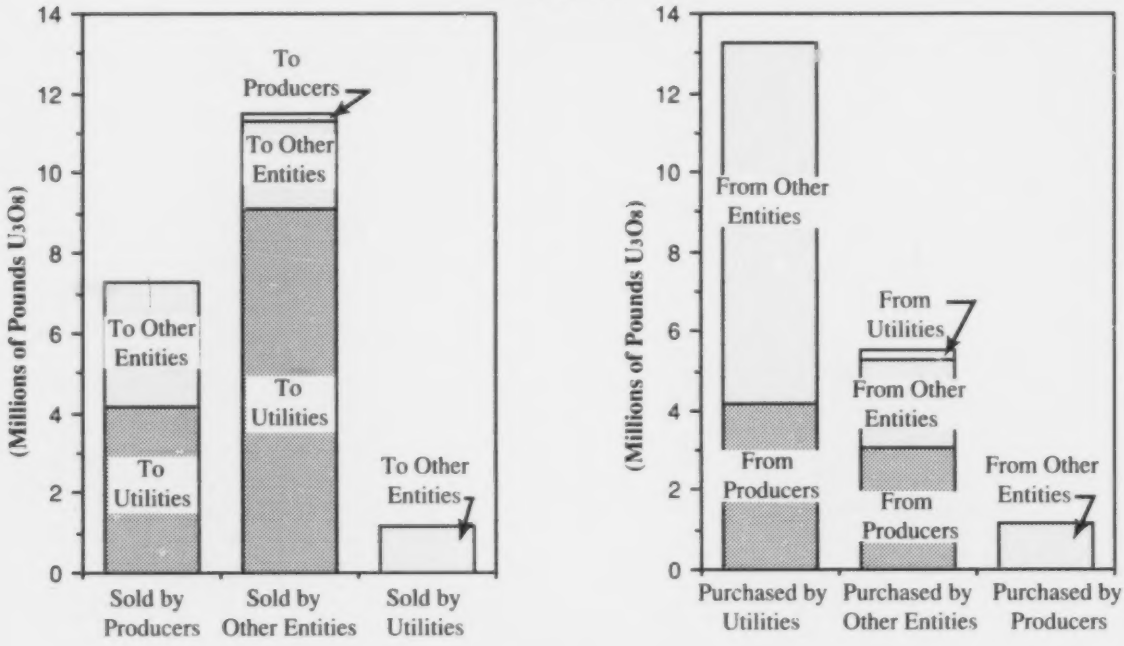

Table 3

TRANSACTIONS: SPOT OR NEAR-TERM URANIUM SALES[1] REPORTED BY NUEXCO, 1985 TO 1987

(Millions of pounds U_3O_8 equivalent)

SELLERS	BUYERS											
	Utilities			Other Entities			Producers			Total		
	1985	1986	**1987**	1985	1986	**1987**	1985	1986	**1987**	1985	1986	**1987**
Producers	4.67	5.87	**4.16**	1.64	1.56	**3.10**	1.72	0.18	**0.00**	8.03	7.61	**7.26**
Other Entities	2.25	1.86	**9.10**	0.36	0.05	**2.20**	0.34	0.00	**0.22**	2.95	1.91	**11.52**
Utilities	3.50	0.74	**0.00**	1.05	0.08	**1.14**	0.00	0.75	**0.90**	4.55	1.57	**1.14**
Total	10.43	8.47	**13.26**	3.05	1.69	**6.44**	2.06	0.93	**0.22**	15.54	11.09	**19.92**

[1]Does not include transactions which fall into one or more of the following categories:

a. Transactions which took place in 1986 but were reported in 1987;

b. transactions which involved fabicated fuel;

c. transactions that Nuexco was aware of but chose not to report, either to protect client confidentiality or because Nuexco was not satisfied with the reliability of our information, and/or;

d. a negotiation which has not advanced to such a degree that Nuexco would judge it a completed transaction. Because of the subjective nature of Nuexco judgments, some pending negotiations may have been reported as transactions only to fall through later. In these cases, the transaction was omitted from the table.

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Following the FTA announcement, the Premium dropped steadily to the $0.65 level as of the end of 1987. Early in January 1988, the Supreme Court agreed to review the US producers' lawsuit (i.e., ageed to grant *writ of certiorari*), indicating to some observers that the Supreme Court could even overrule the previous decisions. That action has been primarily responsible for the further decline in the Premium, to the $0.15 level at the end of March 1988.

The Preservation of US-Origin Uranium

A number of US utilities, concerned about possible restrictions, utilized a variety of means to preserve their inventories of US-origin material. A large number and variety of origin-swap transactions took place throughout 1987, both between utilities and intermediaries, and on the part of utilities acting on their own to rearrange their stocks of uranium held in different forms. A common method was the internal swap between material of non-US origin and material of US-origin. For example, some utilities swapped the US-origin label from material in the form of natural or enriched UF_6 into U_3O_8 stocks, thereby enabling them to load the non-US-origin material into the reactor and preserve the US-origin in inventory.

Utilities also purchased swaps or exchanges. Swap costs tended to be roughly half of the US Premium at any given time, and as the Premium rose and fell, so did the value of swaps. In the second half of the year, increased attention to swaps by the Nuclear Regulatory Commission (NRC) caused a general decline in the volume of "paper swap" transactions, and an increase in the number of book-transfer exchanges of material to accomplish the same purpose. At present, the NRC and other organizations are reviewing "paper swap" rules and procedures, and are expected to clarify the guidelines for such transactions in the future.

The philosophy of preserving US-origin material also affected a number of utilities' purchasing decisions during 1987. Non-US producers, primarily Canadians, were able to conclude a number of sales for immediate delivery in the USA because of the strategy by some utilities of buying non-US-origin material and immediately delivering it into the enrichment pipeline. US-origin stocks that would have entered the pipeline (and the reactor) were held in inventory and replaced by the recently purchased non-US-origin material. As the prospects for any near-term restrictions dimmed, more buyers utilized this method. The risk that restrictions would be enacted in the roughly three-month period between delivery of concentrates to the converter and delivery of UF_6 to the DOE enrichment account, combined with the Canadian upgrading requirement, led a number of these displacement buyers to contract for natural UF_6 as opposed to U_3O_8.

Effect of Origin on Long-Term Contracting

The uncertainty surrounding the origin issue made long-term contracting a difficult process for US utilities. Although unfilled requirements in the US market are projected to rise from approximately ten million pounds U_3O_8 equivalent in 1989 to over thirty million pounds U_3O_8 by 1994, only a few US utilities signed long-term supply contracts during 1987. This is remarkable particularly when considering the market's current weakness, for base prices under long-term contracts are subject to an increasing influence from spot-market prices.

The most competitive long-term sellers tended to be non-US producers, but US utilities were cautious about contracting while the origin issue was unsettled. Some utilities that entered long-term negotiations later withdrew because of the legal and political uncertainties; others required bidders to offer alternate sources of supply or "walkaway" provisions if the contract was signed but the delivered uranium could not be used by the utility. The uncertainty over the eventual method of "grandfathering" older contracts, if restrictions were applied in the future, contributed to the confusion. Various drafts of pro-uranium legislation circulating in the US Congress had specific grandfather provisions; i.e., contracts signed before a given date were exempt from the restrictions. However, the judicial rulings in the producers' lawsuit have contained no such provisions for contracts. Proportionally (based on the relative sizes of nations' nuclear programs), and considering the notable unfilled requirements in the USA in the 1990s, the degree of long-term contracting by US utilities was relatively insignificant in 1987.

Long-term contracting outside the USA remained relatively constant compared to previous years. One significant development outside the US was the signing of the third long-term U_3O_8 contract between the China Nuclear Energy Industry Corporation (CNEIC) and a European company, and the start of negotiation toward a fourth such contract, which was concluded early in 1988. Four European countries now have contracted with China as a long-term uranium supplier, possibly at the expense of African producers whose material is governed by similar safeguards controls.

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MARKET DEVELOPMENTS

Transaction Analysis

During the twelve months from January 1987 through December 1987 (Reports 222 to 233, February 1987 to January 1988), Nuexco reported 85 spot transactions for the sale of uranium contained in U_3O_8 concentrates, natural UF_6 and enriched UF_6. Using additional information available at the time of this report, Nuexco has included in its calculations 11 other transactions that were not reported in 1987, for a total of 19.9 million pounds U_3O_8 equivalent transacted during the year for spot and near-term delivery (Tables 3 and 4, and Figure 2).

Nuexco's reporting of nuclear fuel transactions is subject to some limitations, and some transactions may not have been included because of one or more of the following circumstances.

1. Transactions (or certain information about published transactions) whose reporting would jeopardize client confidentiality are not reported by Nuexco.

2. Transactions about which insufficient reliable information could be ascertained are not reported.

3. New deliveries, or the exercise of options for additional material under old contracts are not regarded as new transactions and are not reported. Similarly, renegotiations of old contracts are not included as new transactions.

4. 1987 transactions which took place in 1986 but were reported in early 1987 are not reported, nor were transactions involving material other than U_3O_8, natural UF_6, or low-enriched uranium.

5. Transactions involving back-to-back sales, although two sales contracts are involved, generally are reported as only one transaction. However, in the case of trading activities, depending on Nuexco's knowledge of the transactions involved, both (or more) sides of the transaction may be reported separately.

Table 3 shows the aggregate totals of the transactions used in the transaction analysis, by seller and buyer groups. Of the 96 uranium sales transactions analyzed for 1987, 31 involved natural UF_6, 58 involved concentrates, and 7 involved low-enriched uranium. In terms of quantities delivered (or to be delivered), approximately 7.1 million pounds U_3O_8 equivalent (35.5 percent) were in the form of natural UF_6, 11.4 million pounds (57 percent) were in the form of concentrates, and 1.5 million pounds equivalent U_3O_8 (7.5 percent) consisted of low-enriched uranium.

The Buyers — As has been the case in previous years, utilities purchased the bulk of uranium sold in the spot market (66 percent of the total, down from 76 percent in 1986). However, by far the largest share of utility purchases were made from intermediaries, rather than through direct sales from producers. Intermediaries supplied approximately 69 percent of the uranium bought by utilities, while producers supplied only 31 percent. By contrast, in 1986, intermediaries sold only about 22 percent of the material bought by utilities, and producers sold 69 percent. This change is one indicator of a fundamental shift in spot market operation, with an increasing emphasis on brokerage and trading activity. Transactions have become ever more complex due to such considerations as material origin, time and place of delivery, and financing, creating a niche for intermediaries. Some producers also developed the resources necessary to engage in limited trading activity.

Altogether, intermediaries purchased nearly a third (32.3 percent) of the total spot market volume; of this amount, about half (48 percent) was bought from producers, about one-third (34 percent) from other intermediaries, and the remainder (18 percent) from utilities. For perhaps the first time, in 1987 a significant transaction volume was carried out *between* intermediaries — about 11 percent of the total volume, or over 2.2 million pounds U_3O_8 equivalent.

The Sellers — For the first time, intermediaries were the largest group of sellers in the spot market, transacting 58 percent of total market volume in 1987. Producers sold 36 percent of the total. This marks a dramatic increase in intermediaries' presence in the market — in 1986, intermediaries sold only about 17 percent of the total volume, and producers sold almost 70 percent. Total sales by utilities declined from 1.6 million pounds equivalent U_3O_8 in 1986 (14 percent) to 1.1 million pounds in 1987 (less than 6 percent of the total), as inventory liquidations have virtually stopped. However, over 85 percent of the 1986 figure was due to one large concentrates sale and a large sale of low-enriched uranium.

US-Origin — The market for US-origin material was closely tied to several judicial and political events that took place in 1987. During the first half of the year, demand for US-origin material was relatively weak, as US utility buyers were unwilling to commit to purchases of that origin if not faced with legal or legislative restrictions on lower-priced imports (through restrictions on enrichment at DOE). However, when in July 1987 the US Tenth Circuit Court of Appeals upheld Judge Carrigan's 1986 decision mandating import restrictions (subsequently appealed to the Supreme Court by DOE), many US utilities felt the need to buy US-origin, stimulating the market for that origin uranium. Even though demand gradually slackened toward the end of the year, sales of US-origin material

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Table 4

FORM AND ORIGIN OF MATERIAL PURCHASED IN 1985 TO 1987: SPOT AND NEAR-TERM TRANSACTIONS REPORTED BY NUEXCO

Transaction Subgroup	Millions of pounds U_3O_8 equivalent			Percent of Total Quantity		
	1985	1986	**1987**	1985	1986	**1987**
U_3O_8 Concentrates	10.4	4.68	**11.36**	67	42	**57.0**
Natural UF_6	4.9	5.65	**7.06**	31	51	**35.5**
Enriched UF_6	0.2	0.76	**1.50**	2	7	**7.5**
TOTAL	15.54	11.09	**19.92**	100	100	**100**
US-origin[1]	n.a.	5.63	**5.08**	n.a.	57	**25.5**

[1]Nuexco estimate.

totaled over 5 million pounds U_3O_8 equivalent. Although the quantity of US-origin sold was only slightly less than in 1986, the percentage of the total was considerably less — US-origin material accounted for 51 percent of the total in 1986, versus 25 percent in 1987.

Transaction Value

The Transaction Value (TV, Table 5) published monthly by Nuexco is a weighted average of prices paid for natural uranium in spot and near-term transactions of at least three immediately preceding months. The conditions for the calculation stipulate that at least ten transactions, totaling at least 2 million pounds U_3O_8 equivalent, must be included in each calculation, and that the sample time must be extended beyond three months as necessary to include these minima. Transactions included in the TV calculation generally are a subset of those listed under the category "Uranium Sales" in the *Current Market Data* section of each Report. Because of the inclusion of transactions from at least three months, the TV historically trails the Exchange Value (EV). In addition, because the TV is a historical indicator based solely on prices paid for uranium, it is subject to influence by premium or discount prices, while the EV may not be.

At the beginning of 1987, the TV was $0.55 higher than the EV, as premiums paid by US utilities for US-origin uranium in the second half of 1986 influenced the TV. These premiums were generally between $0.25 to $1.00 per pound U_3O_8, relative to the EV, and tended to offset discounts obtained by some buyers for non-US-origin material. However, the slack market for US-origin in the first half of 1987 was reflected in the TV as it dropped to equal the EV at the end of March. The TV stayed near the EV until July, when the strengthening market for US-origin again began influencing the TV, causing it to reach $1.55 higher than the EV in September. From that point, through the end of the year, the TV gradually declined in step with the market for US-origin material.

The TV for January 31, 1987 through December 31, 1987 included a total of 89 transactions, and a total quantity of 16.5 million pounds U_3O_8 equivalent. Of that total, 32 transactions and 4.4 million pounds were US-origin material. The weighted annual average Transaction Value includes only those transactions and each is counted only once. The sum of the 1987 transaction quantities is divided into the sum of price times quantity calculations, giving a weighted average for the 1987 transactions included in the TV. This average is *not* the same number as would be found by simply averaging all twelve months' Transaction Values.

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Secondary Market Conversion

Throughout 1987, the Conversion Value remained within a narrow range, between $1.80 and $1.90 per pound U as UF_6 (approximately $4.00 per kg U as UF_6). Thus the Conversion Value has shown little movement over the past two years. Both supply and demand for secondary market conversion services was intermittant, and competitive UF_6 prices allowed many potential conversion buyers to purchase UF_6 rather than conversion alone. Ten conversion sales took place in 1987 (Table 6), involving a total of approximately 2.2 million pounds U as UF_6 (about 1 million kg U as UF_6). This figure is almost the same as that in 1986. Intermediaries figured in nearly all transactions, many of which involved *deconversion* of UF_6, and most of the conversion buyers were US utilities. There were few attempts by utilities to dispose of unwanted conversion commitments with primary suppliers during 1987. Prices generally were near the Conversion Value current at the time of the transaction, except in Europe, where volume was limited and prices were generally higher.

Table 5

1987 TRANSACTION VALUES[1]
(and associated parameters)

Calculated as of the Last Day of the Month	Report Number	Transaction Value (per lb. U_3O_8)	Millions of Pounds	Number of Transactions	Number of Months
January	222	$17.35	2.4	16	5
February	223	$16.90	2.5	12	3
March	224	$16.95	3.8	20	3
April	225	$17.00	4.9	23	3
May	226	$17.20	3.1	17	3
June	227	$17.10	3.5	13	3
July	228	$17.30	3.8	19	3
August	229	$17.55	4.2	19	3
September	230	$18.20	3.2	14	3
October	231	$18.05	3.7	17	3
November	232	$17.80	3.3	18	3
December	233	$17.20	3.9	23	3
Annual Average		$17.34[2]	3.5	17.6	3

[1]The Transaction Value is a weighted-average price of recent natural uranium sales transactions. The calculation is based on prices paid in:
a. Transactions closed within the previous three-month period for which delivery is scheduled within one year of the transaction date;
b. At least ten transactions;
c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent.
The sample time is extended as necessary to include these minima. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

[2]This average is a weighted average.

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Natural Uranium Loans

The Loan Rate showed almost no movement during 1987 (Table 6), remaining in the vicinity of 3 percent per annum. Activity in the market for uranium loans increased substantially over 1986. Nuexco is aware of eight loan transactions taking place, involving over 5 million pounds U_3O_8 equivalent. Nearly all of those transactions were for UF_6. Several European utilities loaned material to intermediaries, and US utilities and producers also borrowed material. Overall, substantial quantities of material were available for loan throughout the year, while loan demand was generally weak. Some potential borrowers, particularly producers wishing to borrow material that they could sell to finance production activities, were unable to meet the stringent security requirements of lenders or found terms and conditions too restrictive. Low uranium prices also inhibited lending, as purchasing often was a more attractive option than borrowing.

Table 6

1987 URANIUM LOANS AND SECONDARY MARKET CONVERSION TRANSACTIONS REPORTED BY NUEXCO

	Number of Transactions	Quantity
Secondary Market Conversion Transactions	10	2.18 million pounds U as UF_6 (989 MTU as UF_6)
Loan Transactions	8	5.11 million pounds U_3O_8 equivalent) (1,960 MTU as UF_6)

1987 NUEXCO URANIUM LOAN VALUES AND CONVERSION VALUES

Month	Report Number	Conversion Value (US $)	Loan Value
January	221	1.80	4%
February	222	1.80	3%
March	223	1.80	3%
April	224	1.80	3%
May	225	1.80	3%
June	226	1.80	3%
July	227	1.80	3%
August	228	1.90	3%
September	229	1.90	4%
October	230	1.90	4%
November	231	1.90	4%
December	232	1.90	3.5%

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ENRICHMENT SERVICES

Supply, Demand and Prices

Abundant supplies of low-priced SWU offered by a number of utilities and primary suppliers such as Techsnabexport (TSE) and the China Nuclear Energy Industry Corporation (CNEIC), combined with relatively small and intermittent demand, caused the SWU Value to decline steadily during most of 1987. It fell from $80 in January 1987 to $69 in October, its lowest level since Nuexco began publishing a SWU Value in 1983, and closed the year at $73 (Table 7). Both TSE and CNEIC undercut prices offered by Western sources in an effort to increase market share, and concluded several sales into Europe in particular. Several European utilities exercised flexibilities in their enrichment contracts, in order to take advantage of the low secondary market prices.

In 1984, when DOE introduced the USEC (Utility Services Enrichment Contract), the worldwide SWU market underwent substantial restructuring. During 1987, DOE directly supplied over 80 percent of utility SWU requirements in the USA and Far East, with Eurodif supplying most of the balance of long-term requirements in those regions. In the European market, Eurodif supplied most of the enrichment to utilities in France, Belgium and Spain, while Urenco was the main supplier to utilities in Germany and the UK. Other countries across the Continent chose an even mix of other suppliers. Only a few utilities were totally uncovered for enrichment requirements and they accounted for a significant portion of the activity in the secondary market.

As in previous years, those utilities with no long-term enrichment coverage purchased all of their near-term requirements in the secondary market during 1987. Other secondary market buyers included USEC holders that were committed to DOE for 70 percent of their requirements, having elected not to accept DOE's Incentive Price option covering 30 percent of requirements. In addition, a few long-term TSE contract holders with requirements above their fixed commitments chose to cover those needs in the secondary market.

Transaction Analysis

Nuexco reported the sale of approximately 2.05 million SWU in 25 spot and near-term transactions during 1987 (Table 8). Eight of the reported transactions involved the sale of enriched uranium product (EUP), which includes the feed component as well as SWU. (Transactions reported by Nuexco may not include all secondary market sales that occurred during the year, and Nuexco may choose not to report certain deals due to inadequate information or for other reasons.)

Table 7

1987 SWU VALUES

Determined as of the Last Day of the Month	Published in Report Number	Nuexco SWU Value
January	222	$80
February	223	$80
March	224	$77
April	225	$77
May	226	$75
June	227	$73
July	228	$75
August	229	$75
September	230	$73
October	231	$69
November	232	$73
December	233	$73
Annual Average		$75

Intermediaries, including brokerage and trading companies, other entities and even DOE acting on behalf of utility customers, were involved in almost every significant transaction. Trading companies sold material of Soviet and Chinese origin in Europe and structured complex transactions involving excess Eurodif and DOE-origin material to other intermediaries and utilities. Only a small portion of the SWU sold in the secondary market was of Urenco origin, due to limited inventories. Nuexco is aware of seven European utilities that purchased SWU in the secondary market during the year; several others may have been involved in inventory rearrangements. In the US market, two US utility sellers liquidated a total of some 400,000 SWU, and at least seven US utilities purchased in the secondary market. Some buyers in Europe and the USA purchased SWU on more than one occasion.

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Table 8 analyzes secondary market enrichment sales to utility end-users estimated by Nuexco to have occurred during 1987, with deliveries scheduled for 1987 or 1988. (Data do not correspond to all transactions reported by Nuexco during 1987, since some reported transactions involved sales to intermediaries. Data may have been revised after original transaction reporting in 1987 or during 1988.) The table illustrates the prevalence of DOE-origin material in the US market and the emergence of TSE-origin material as a principal source of secondary supply to European end-users. The sales of Chinese-origin EUP marked the first such sales to Western companies and could signal the entry of a competitive new participant in the secondary SWU market.

Table 8

SECONDARY MARKET SWU TRANSACTIONS[1] REPORTED BY NUEXCO IN 1987

Region	Quantity of SWU by Origin (Thousands of SWU) DOE	TSE	EDIF	CNEIC	No. of Trans-actions
United States	480	90	110	—	8
Europe	—	455	35	65	8
TOTAL	480	545	145	65	16

[1]Only includes transactions which occurred in 1987. Does not include transactions for which Nuexco has incomplete or unreliable data. Some transactions may have been updated after original publication.

Developments in the Long-Term Enrichment Market

Little sales activity in the long-term enrichment market occurred during 1987. Some renegotiation of existing long-term contracts did take place in Europe, but resulted in no significant net change in the long-term SWU supply and demand situation.

Eurodif S.A. did not report any changes in the production capacity, ownership or marketing strategy of the enrichment consortium. (The Eurodif gaseous diffusion plant, located at Tricastin, France, has a nominal capacity to produce 10.8 million SWU per year and has been operating since the early 1980s). However, the current agreement among the members of the consortium including Cogema (France), Synatom (Belgium), Enusa (Spain), and Agip S.P.A. and the CNEA (Italy), is expected to be renegotiated by the early 1990s. At that time, investment in the plant may be fully recovered, resulting in a different cost structure, and the long-term interests of the partners should be clarified. The degree to which French policy may guide the consortium is one of the issues in question as Cogema proceeds with the development of laser enrichment technologies and other independent fuel cycle ventures. EdF (Electricite de France) is by far the largest Eurodif customer, taking over half the annual production.

The production capacity of the Urenco consortium continued to expand with the installation of new centrifuge modules at all three plants. Urenco, owned by British, Dutch and German companies, operates centrifuge enrichment plants at Capenhurst in the UK, Almelo in the Netherlands, and Gronau in the Federal Republic of Germany. Total annual production capacity of the enterprise was estimated to be over 2 million SWU at the end of 1987, and is expected to grow to nearly 3 million SWU by 1990 and 5 million SWU by the mid-1990s. Capacity additions have been scheduled to match closely the addition of new nuclear generating capacity in the three countries where plants are located.

Techsnabexport (TSE) continued to be a reliable supplier of enrichment services to its long-term utility customers in Europe. Companies in eight western European countries are known to have long-term arrangements with TSE, entered into during the 1970s. TSE actively sought additional long-term business during 1987, but Nuexco is not aware of any new long-term contracts. In the Far East, CNEIC indicated an interest in pursuing long-term enrichment business, and the Japanese nuclear industry continued development planning for domestic centrifuge operations.

US DOE

At the beginning of 1987, DOE faced three major issues which raised questions as to its commercial viability:

1. a dispute with TVA over demand charges for power;
2. the uranium producers' lawsuit which threatened to restrict DOE's ability to enrich foreign uranium for US customers, and;
3. disputes with US government auditors on its debt to the US Treasury. By the end of 1987, DOE had reached a

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settlement with TVA on the demand charges at a small discount from TVA's asking price.

The other two issues were carried over into 1988. The uranium producers' lawsuit is covered in detail in the *United States* section of this report, but the July 1987 decision of the appeals court in favor of the producers did not affect DOE's business due to DOE's appeal to the US Supreme Court. The debt issue remained open at the end of the year, as did the possibility of restructuring DOE's enrichment enterprise into a separate corporation.

DOE sold about 10 million SWU in fiscal 1987, with only about 4 million SWU coming from production, as DOE continued to draw down inventories. Production is planned to continue at low levels through 1989 when the inventory will be reduced to minimum working levels.

DOE also set a new policy in 1987 when it offered SWU to customers that had not previously committed to take their requirements from DOE. The source of this SWU was a DOE customer with excess commitments, and the offered price of $75 compared favorably to the $90 per SWU incentive price provided to customers that had previously committed to DOE. While this offer was in line with DOE's announced policy of negotiating individually with its customers, it was a departure from a 1984 promise that customers that committed to the USEC contract would receive the most favorable treatment.

Enrichment of Reprocessed Uranium

In April 1987, DOE announced that it was revising its specifications for UF_6 feed material effective October 1, 1988. The new specifications drastically reduced the allowable U236 and U232 contamination levels for "natural" UF_6 and created a new category for reprocessed UF_6. The new specifications signalled a change in DOE policy on reprocessed uranium in response to a growing quantity of this material.

Reprocessed uranium, referred to as "REPU" or "RU", contains U232 and U236 isotopes which are considered undesirable contaminants. The U232 isotope has daughter products which emit gamma rays, and may require additional shielding of workers depending on concentration. U236 is a neutron absorber, or "poison", and will reduce the reactivity of the fuel unless offset by increased U235 enrichment. While the problems created by the presence of these isotopes are not insurmountable, they do create economic penalties. Previously, the quantity of reprocessed uranium from DOE's commercial and military customers was small enough that DOE could "trickle" the material into the mainstream of natural uranium being processed without raising objections. With the increased quantities of reprocessed material being delivered to DOE, they now have promised to segregate the REPU so that it does not contaminate the mainstream material. It is probable that DOE and other enrichers will initiate surcharges for handling reprocessed material, similar to the surcharges discussed by fabricators.

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WORLD URANIUM PRODUCTION IN 1987

World uranium production, excluding Eastern Bloc countries (for which little reliable information is available), totaled approximately 94.9 million pounds U_3O_8 (about 43,000 metric tonnes U_3O_8) in 1987, a 2.5 percent drop from the 1986 figure of 97.3 million pounds (Table 9; some historical world production figures are given in Table 10). Of the top four producing countries, Australia, South Africa and the USA registered decreases, while Canada, the foremost producer, increased output in 1987.

1987 Results

Australia — Australia's 1987 production totaled approximately 9.8 million pounds U_3O_8, a decrease of about one million pounds from the 1986 figure of 10.8 million pounds. Australia's share of the world uranium market also decreased slightly, from approximately 11.2 percent in 1986 to 10.3 percent in 1987. 1987 production came entirely from two producers, Energy Resources of Australia (ERA) and Queensland Mines Limited (QML).

Canada — For the fourth year in a row, Canada led the world in uranium production in 1987, accounting for more than one-third of all U_3O_8 production worldwide. Canadian mining and milling centers produced 32.3 million pounds U_3O_8 in 1987, a six-percent increase from the 1986 level .

The province of Saskatchewan was responsible for about two-thirds of this total output, as the Key Lake project again exceeded its 12-million pound rated capacity. Key Lake production totaled slightly more than 13.5 million million pounds U_3O_8, an increase of almost one million pounds over the previous year's record output.

South Africa and Namibia — Uranium production in the Republic of South Africa continued to decline in 1987, to approximately 10.3 million pounds U_3O_8. This is a drop of 14.2 percent from the previous year's total of almost 12 million pounds. These figures include production from both Chamber of Mines producers and the Palabora Mining Company. Part of the decline resulted from labor disruptions caused by the lengthy strike called by the Mineworkers Union, which caused third-quarter output to drop substantially at several mines. In Namibia, Rossing Uranium Ltd.'s Rossing project maintained steady production, estimated at 9.2 million pounds U_3O_8, a slight increase over 1986.

USA — US uranium production of approximately 12.5 million pounds U_3O_8 represented a decline of about 10 percent from 1986, when 13.8 million pounds were produced. Conventional production accounted for about 62 percent of the total, little changed from the previous year, while solution mining accounted for 8 percent (down from 11 percent) and by-product production from phosphates amounted to about 30 percent (up from 26 percent).

Table 9

WORLD URANIUM PRODUCTION IN 1986 AND 1987
(Millions of Pounds U_3O_8)

Country	1986	1987	Percent Change
Australia	10.8	9.8	- 9.3
Canada	30.5	32.3	+ 5.9
France	8.5	8.6	- 1.2
Gabon	2.2	2.1	- 4.5
Namibia	9.1	9.2	+ 1.1
Niger	8.2	7.8	- 4.9
South Africa	12.0	10.3	- 14.2
United States	13.9	12.5	- 10.1
Other[1]	2.1	2.3	+ 9.5
WORLD TOTAL	97.3	94.9	- 2.5

[1]Includes Argentina, Belgium, Brazil, China, India, Pakistan, Portugal, Spain and Yugoslavia.

Other Countries

Europe — Uranium production in Europe increased about 2 percent over 1986, led by France, whose 1987 output totaled 8.6 million pounds U_3O_8. In France, Cogema accounted for 84 percent through its operations at Herault, Vendeed, Crouzille and Langogne. Total Compagnie Miniere-France produced the remainder at its Chebois unit in Haute-Vienne.

Spanish uranium production increased marginally, to 572,000 pounds U_3O_8. Portuguese production remained steady at about 350,000 pounds U_3O_8 from Urgeirica. In Belgium, by-product uranium from phosphoric acid production declined to 91,000 pounds from the 1986 level of about 120,000 pounds U_3O_8.

In Germany, Saarberg-Interplan produced approximately

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50,000 pounds U_3O_8 from its test mining program at the Grossschloppen project, and Gewerkschaft Brunhilde continued production at Ellweiler at a rate of about 90,000 pounds U_3O_8 per year. The Zirovski project in Yugoslavia increased output 30 percent over 1986, to 234,000 pounds U_3O_8.

Asia — India remained the largest uranium producer in Asia, outside of China, with 1987 production from both conventional and copper by-product operations estimated to be 360,000 pounds U_3O_8. China produces significant quantities of uranium, but information on Chinese production is highly classified by the government, and much of their production is for military purposes. Japan produces a few thousand pounds U_3O_8 per year from various pilot programs. Pakistan is reported to have recently started up a uranium production complex at Dera Ghazi Khan, with an estimated capacity of about 60,000 pounds U_3O_8 per year.

Central Africa — Compagnie des Mines d'uranium de Franceville (COMUF) produced 2.1 million pounds U_3O_8 at its Mounana operation in Gabon, down slightly from the 1986 total of 2.2 million pounds. Niger's 1987 output of 7.8 million pounds U_3O_8 from its Arlit and Cominak operations represent a 5-percent decrease from 1986, all of which is attributable to the Arlit mine, where production has declined from over 5,000,000 pounds in 1982 to 2.6 million pounds U_3O_8 in 1987.

South America — In Brasil, Nuclebras increased production at its Pocas de Caldas complex from 77,000 pounds U_3O_8 in 1986 to 252,000 pounds in 1987. Production in Argentina decreased by 7 percent as the Malargue project was closed and the Los Gigantes project experienced continuing production difficulties. Total 1987 production was approximately 250,000 pounds U_3O_8.

Table 10

HISTORICAL WORLD[1] URANIUM PRODUCTION[2], 1983-87
(Millions of Pounds U_3O_8)

	Production/ Market Share[3] 1983	1984	1985	1986	Production/ Market Share[3] 1987
Australia	8.4 (8.8%)	11.4	8.5	10.8	**9.8** (10.3%)
Canada	18.6 (19.4%)	29.0	28.3	30.5	**32.3** (34.0%)
France	8.5 (8.9%)	8.2	8.3	8.5	**8.6** (9.1%)
Gabon	2.6 (2.7%)	2.4	2.4	2.2	**2.1** (2.2%)
Namibia	9.7 (10.1%)	9.6	9.0	9.1	**9.2** (9.7%)
Niger	8.9 (9.3%)	8..6	8.2	8.2	**7.8** (8.2%)
South Africa	15.7 (16.4%)	14.9	12.6	12.0	**10.3** (10.9%)
United States	21.2 (22.1%)	14.9	11.3	13.9	**12.5** (13.2%)
Other[4]	2.2 (2.3%)	2.0	2.0	2.1	**2.3** (2.4%)
WORLD TOTAL	95.8	101.0	90.6	97.3	**94.9**

[1]Outside Soviet bloc areas.
[2]Figures presented are Nuexco's best estimates.
[3]Expressed as a percentage of total production. Column may not equal 100 percent due to rounding.
[4]Includes Argentina, Belgium, Brazil, India, Pakistan, Portugal, Spain, and Yugoslavia.

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AUSTRALIA

Combined production during 1987 of 9.8 million pounds U_3O_8 by Queensland Mines Limited (QML) and Energy Resources of Australia (ERA) enabled Australia to retain its fourth place ranking amoung uranium producing nations (after Canada, the USA, and South Africa). Although QML expects to finish milling the ore stockpiled at its Nabarlek site by midyear, Australia's 1988 production totals should not be adversely affected, for the Olympic Dam project (Figures 3 and 4) is scheduled to begin production, at an annual rate of 4.2 million pounds U_3O_8, at about the same time.

Australian government involvement with uranium appears increasingly pragmatic, as opposed to political, with public debate and discussion of such matters as floor prices and the three-mine policy noticeably muted. While still capable of provoking controversy on occasion, uranium is no longer quite the volatile issue of years past, and neither Labor nor the Liberals seem inclined to push it back into the political spotlight. Much of the recent public commentary has tended to focus on the need for greater market responsiveness and flexibility, including consideration of adjustment and/or elimination of policies that limit growth and mandate specific commercial terms. This trend was evident in the approach taken by CRA Ltd.'s Canning Resources subsidiary in announcing its Kintyre uranium discovery in Western Australia, and the following aggressive pre-production campaign to interest potential customers.

Production Results

Queensland Mines — QML's Nabarlek project in the Northern Territory produced nearly 3 million pounds U_3O_8, all from stockpiled ore. QML continued to deliver uranium to customers in Japan and in Europe, and a modest contract extension was concluded with one customer. It is estimated that the ore stockpile now contains less than one million pounds of additional, recoverable U_3O_8, and that milling operations will be concluded by mid-1988. At that time, the company must either put the mill on a care-and-maintenance basis or begin the cleanup and decommissioning process. Although QML currently lacks sufficient uncommitted production from Nabarlek to compete with other Australian sellers in the long-term market, negotiations with the Northern Land Council are progressing with respect to QML's gaining new exploration rights in the potentially uranium-rich areas surrounding Nabarlek.

Figure 3. Aerial View of Machinery Entering Decline Portal, Olympic Dam Project.

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AUSTRALIA

Figure 4. Tamrock Jumbo Drilling, Olympic Dam Project.

Energy Resources of Australia — ERA's Ranger mine at Jabiru produced 6.8 million pounds U_3O_8, down somewhat from the 1986 level of 7.7 million pounds. ERA concluded new long-term contracts with two US utilities, bringing the number of its US contracts to eleven, and it is likely that two more such contracts will be announced in the first half of 1988. A new long-term contract with Electricite de France was signed, as part of Cogema's purchase (from Germany's Saarberg Interplan) of a 1.25 percent interest in ERA, the first such French equity participation in a producing Australian uranium project.

ERA is also reported to have reached agreement with its shareholder-customers on a number of contract issues that have been in contention for some years. While the exact terms have not been made public, the settlement reportedly included lower prices, as well as additional tonnage, contract extensions, and the limitation of certain termination rights.

Olympic Dam — Development of the mining and milling facilities and associated infrastructure continued during 1987 (Figures 3 and 4), and the startup of this large, multi-mineral operation remains on schedule for mid-1988. Annual uranium production is targeted at 4.2 million pounds U_3O_8, of which about 50 percent is currently under long-term contract. A 1986 contract with the Swedish State Power Board was followed in 1987 by contracts with the UK's Central Electricity Generating Board and Korea Electric Power Company, and a contract with a Japanese utility is reportedly under negotiation. Given the current state of the uranium market, it appears doubtful that Olympic Dam's full capacity will be under contract when production begins later this year.

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CANADA

Uranium Production and Exploration

For the fourth year in a row, Canada led the world in uranium production in 1987, accounting for more than one-third of all U_3O_8 production worldwide. Canadian mining and milling centers produced 32.3 million pounds U_3O_8 in 1987, a six-percent increase from the 1986 level (Table 11).

The province of Saskatchewan was responsible for about two-thirds of this total output, as the Key Lake project (Figure 5) again exceeded its 12-million pound rated capacity. Key Lake production totaled slightly more than 13.5 million pounds U_3O_8, an increase of almost one million pounds over the previous year's record output. The **Key Lake Joint Venture** is owned by the Saskatchewan Mining Development Corp. (SMDC, 50 percent), Uranerz Exploration and Mining (33.3 percent), and Eldorado Resources (16.7 percent). The milling of high-grade ore from the Collins "B" orebody increased output at **Eldorado Resources'** newly-renovated Rabbit Lake mill to 5.7 million pounds, contributing to the overall production increase. At Cluff Lake, **Amok Ltd.** produced 2.15 million pounds U_3O_8, a slight decrease from the 1986 level.

Uranium production in Ontario declined in 1987, partly the result of a three-week strike in the Elliot Lake district. **Denison Mines Ltd.** and **Rio Algom** produced 4.7 million and 6.2 million pounds U_3O_8 respectively in 1987, a drop of approximately 10 percent and 15 percent respectively.

Both exploration and new project development continued in 1987, primarily in Saskatchewan and the Northwest Territories. In October 1987, the Saskatchewan Environment Department gave its approval for test mining of the Cigar Lake deposit, the world's largest high-grade uranium deposit. The **Cigar Lake Mining Corporation**, owner of the project, plans to begin sinking a 500-meter exploratory test shaft in early 1988, as part of a two-year test period that will include site development, and a determination of technical feasibility for full-scale production. The test phase will involve mining up to 5,000 metric tons of ore. Commercial production is expected to begin in 1993.

Table 11

CANADIAN URANIUM OUTPUT, 1986-1987

Company or Mine	Province	Production (Thousands of Pounds U_3O_8) 1986	1987	Percent Change[1]
Denison Mines Limited	Ontario	5,239	4,703	- 10.2
Rio Algom Limited	Ontario			
— Quirke		3,273	3,000	- 8.3
— Panel		2,303	2,000	- 13.2
— Stanleigh		1,737	1,200	- 30.9
Amok Ltd.	Saskatchewan	2,167	2,150	- 0.8
Eldorado Resources Ltd. (Rabbit Lake)	Saskatchewan	3,190	5,699	+ 78.7
Key Lake Joint Venture[2]	Saskatchewan	12,590	13,517	+ 7.4
TOTAL:		30,499	32,269	+ 5.8

[1]From previous year.
[2]SMDC 50%, UEM 33%, Eldorado 17%.

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CANADA

Eldorado Resources also continued to conduct delineation drilling on its wholly-owned Eagle South deposit, as well as on the Eagle North deposit, which is owned by a joint venture of Eldorado, SMDC and Noranda. The two deposits together are estimated to contain over 130 million pounds U_3O_8, with average ore grades between one and two percent U_3O_8. The Saskatchewan Environment Division granted the necessary permits for the development of the Eagle Point and Collins "A" and "D" deposits in January 1988. **Denison Mines** completed the purchase of a 60-percent interest in the Midwest Lake deposit, where it plans to conduct feasibility studies that could lead to shaft development as soon as 1988. **Minatco**, a subsidiary of France's Total Compagnie Miniere, has a permit for underground exploration at its McClean Lake property, but the company has not announced its plans for underground work at that site.

* * *

In January 1987, the provincial government of British Columbia allowed its moratorium on uranium production to expire, a move that is unlikely to have any significant impact in the near-term. The moratorium was imposed in 1980, largely as a result of public opposition to uranium development. The most promising deposit in the province, the Blizzard deposit, owned in part by Ontario Hydro, contains reserves estimated at over 10 million pounds U_3O_8. However, relatively poor ore grades and continued strong opposition to uranium mining in British Columbia are almost certain to preclude commercial development of the deposit in this century.

In its annual assessment of Canada's uranium resources, the Ministry of Energy, Mines and Resources significantly increased reserve estimates. As of the end of 1986, Canada's total known uranium resources (including measured, indicated and inferred categories) were estimated at 567,000 metric tons of uranium (MTU), or almost 1.5 billion pounds U_3O_8. Continuing delineation drilling of deposits in Saskatchewan accounted for most of the 16,000 MTU increase since the 1984 figure, the last time the full assessment was performed.

Nuexco projections indicate that the mining success of the Key Lake Joint Venture will proceed will into the next decade, and Eldorado's use of the Rabbit Lake mill for its next succession of promising deposits at Collins Bay and Eagle Point clearly indicate that Canadian uranium production will continue to surpass that of any other country. Furthermore, the commercial development of Cigar Lake, Midwest Lake and other properties is likely to assure that position well into the next century.

Industry Developments

A number of important developments took place in the Canadian uranium industry during 1987, developments that are certain to have a significant impact on the worldwide uranium market. Perhaps the most interesting, although at present not completed, is the proposed merger of Eldorado Nuclear Ltd. (Eldorado) and the Saskatchewan Mining Development Corp. (SMDC).

On February 22, 1988, the Canadian and Saskatchewan governments announced that a letter of intent had been signed, calling for the merger of Eldorado Nuclear Limited (Eldorado) and the Saskatchewan Mining Development Corporation (SMDC). The merger, to form an as-yet unnamed new company, is targeted for completion by mid-1988, but until finalized, both companies will continue to carry on "business as usual." The merger announcement also noted the commitment to fully privatize the new organization within seven years. The new company would be headquartered in Saskatoon, Saskatchewan. Some of the details thus far released include:

1. *Schedule* — The proposed merger is to be put into effect by July 1, 1988. Before the final agreement can be signed, the Canadian federal government and the government of Saskatchewan must enact enabling legislation, and the merger will be examined for compliance with the Competition Act.

2. *Ownership structure* — The new company will initially be owned by the Saskatchewan government (61.5 percent) and the federal government of Canada (38.5 percent). This ownership distribution is reportedly based on evaluations of the two existing companies' assets and debts and on the potential future contributions of the companies. The founding shareholders in the new company also will receive a debt issue, estimated at about 40 percent of the net assets, in proportion to their share of the holdings.

3. *Privatization* — A divestiture schedule has been established, under which the two government shareholders together will reduce their holdings in the new venture to a total of 70 percent within two years, with further reductions to 40 percent within four years, and to zero percent within seven years.

4. *Controlling Interest and Foreign Participation* — No single Canadian shareholder (or related group) may hold

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shares totaling more than 25 percent of voting rights. Single non-Canadian shareholders (or related groups) will be limited to holdings carrying no more than 5 percent of the voting rights. In total, non-Canadian interests will be prohibited from exercising more than 20 percent of the voting rights.

The new company's holdings will include:

1. *The Key Lake Complex* — 66.7 percent of the Key Lake project, including the mill and associated deposits, estimated to continue producing some 12 to 14 million pounds U_3O_8 annually through at least the end of the century;
2. *The Rabbit Lake Complex* — 100 percent of the Rabbit Lake operation, which, supported by the nearby high-grade Collins Bay and Eagle Point deposits, is projected to produce 5 to 7 million pounds U_3O_8 annually, well into the next century;
3. *Cluff Lake* — 20 percent of Cluff Lake, expected to produce over two million pounds U_3O_8 per year into the next century;
4. *Cigar Lake* — 48.75 percent of the Cigar Lake project, with estimated reserves totaling 385 million pounds U_3O_8 at grades of 5 to 14 percent U_3O_8;
5. *Dawn Lake* — 50 percent of Dawn Lake, with estimated reserves of 30 million pounds U_3O_8 at a grade of approximately 2 percent U_3O_8.
6. *Refining and Conversion Facilities* at Blind River, and Port Hope, Ontario, currently operated by Eldorado.

Assuming that the merger is completed as planned, the resulting new entity would be the world's largest and lowest cost uranium producer. Based on 1987 production results, the two companies' combined production was more than 15 million pounds U_3O_8, representing 16 percent of WOCA production last year. Including only the major deposits associated with the existing Rabbit Lake and Key Lake operations, as well as Cigar Lake and Cluff Lake, the new company would control high-grade reserves currently (and conservatively) estimated to contain over 500 million pounds U_3O_8. In addition, it would hold Eldorado's UF_6 conversion and UO_2 production facilities in Ontario.

Another important development during 1987 was the announced change in government policy regarding foreign

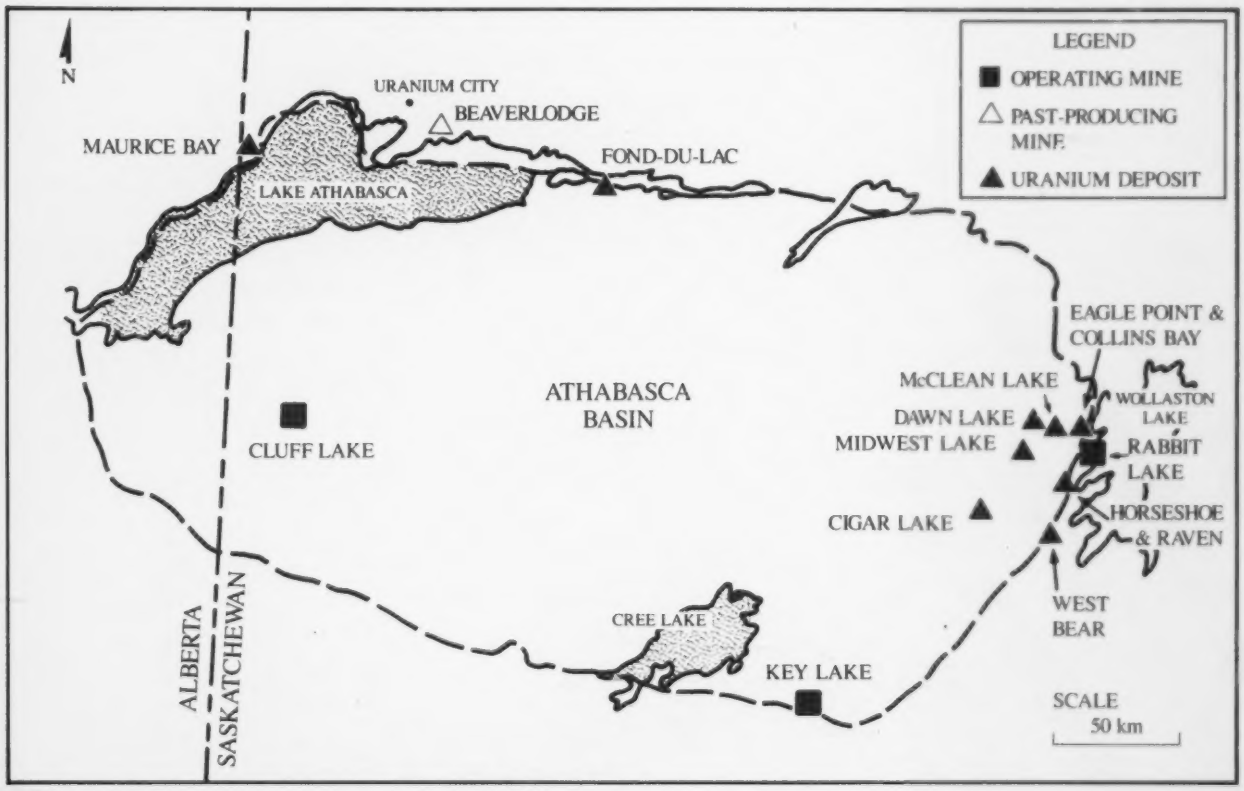

Figure 5. Principal uranium deposits in Saskatchewan.

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ownership of uranium mines. In late December, the federal Minister of State for Forestry and Mines specified that Canadian interests must own at least 51 percent of an individual uranium property when it begins production, a reduction from the 67-percent level required under the previous policy. Exceptions to this 51-percent level may be granted on a case-by-case basis if a Canadian entity maintains a controlling interest in the project, as demonstrated by the recent sale of a two-percent interest in Cigar Lake. Majority-owner SMDC sold a two-percent, non-voting interest in the Cigar Lake Joint Venture to the Korea Electric Power Company (KEPCO) at a price reportedly exceeding C$8 million. Under the terms of the agreement, announced in August 1987, KEPCO will receive approximately 750,000 pounds per year over the period 1993 to 2003. Under the new policy, Canadian companies can share a greater proportion of the financing burden associated with uranium development projects as long as they remain in control. The change in policy is likely to have the greatest impact in Saskatchewan, where high ore grades and potentially attractive deposits may encourage foreign interests to initiate exploration and joint venture programs as a way of diversifying supply sources. Furthermore, it illustrates a more pragmatic approach taken by the Canadian government, which apparently realized that it could promote employment and economic development in a depressed yet crucial industry by allowing greater foreign participation.

Nuclear Power Developments

Ontario Hydro brought one CANDU reactor into commercial service in 1987, following the trend of the last four years. Bruce Unit 8 began commercial operation in May 1987, slightly ahead of schedule, thus completing the eight-unit Bruce station (Table 12). The 5,960-MWe Bruce station is the second-largest nuclear generating station in operation in the world, behind Tokyo Electric Power Company's ten-unit, 9,100-MWe Fukushima station. Canada's total nuclear generating capacity now totals 11,350 MWe, and the four-unit Darlington station is the last active nuclear construction program in Canada. The status of New Brunswick Electric Power Company's Point Lepreau Unit 2 remains uncertain. It had been expected that Energy Minister

Figure 6. New Brunswick Electric Power Commission's Point Lepreau station, a 630-MWe CANDU unit located on the Bay of Fundy. The plant has been in operation since late 1982, and lifetime capacity factor has averaged 92%.

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Table 12

NUCLEAR POWER PLANTS IN CANADA

Utility	Unit	Capacity (MWe Net)	Percent Complete	COD[1]	1987 Capacity Factor[3] (percent)	Total Electricity Generation in 1987[2] (GWh)
In Commercial Operation						
Ontario Hydro	Pickering 1*	515	100	Jul 1971	19	897
	Pickering 2*	515	100	Dec 1971	0	0
	Pickering 3	515	100	Jun 1972	77	3,652
	Pickering 4	515	100	Jun 1973	84	3,989
	Pickering 5	515	100	May 1983	81	3,811
	Pickering 6	515	100	Feb 1984	88	4,179
	Pickering 7	515	100	Jan 1985	97	4,581
	Pickering 8	515	100	Feb 1986	84	3,975
	Bruce 1	740	100	Sep 1977	56	4,404
	Bruce 2	740	100	Sep 1977	51	4,029
	Bruce 3	740	100	Feb 1978	83	6,502
	Bruce 4	740	100	Jan 1979	68	5,412
	Bruce 5	750	100	Sep 1984	79	6,130
	Bruce 6	750	100	Mar 1985	96	7,478
	Bruce 7	750	100	Apr1986	87	6,747
	Bruce 8	750	100	May 1987	69	4,375
New Brunswick EPC[3]	Point Lepreau 1	630	100	Jan 1983	92	5,471
Hydro Quebec	Gentilly 2	640	100	Sep 1983	83	4,270
TOTAL		11,350		*(1987 average)*	71	80,636
Under Construction or Planned						
Ontario Hydro	Darlington 2	881	90	Mar 1989		
	Darlington 1	881	75	Aug 1989		
	Darlington 3	881	30	May 1991		
	Darlington 4	881	20	Feb 1992		
New Brunswick EPC	Point Lepreau 2	990	0	Indefinite		
TOTAL		4,424				

[1]Actual or expected Commercial Operation Date.
[2]Source: *Nucleonics Week*.
[3]EPC=Electric Power Company.
*These units had been shut down for retubing. Pickering Unit 1 reentered service in October 1987, and Unit 2 is expected to reenter service in May 1988.

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CANADA

Marcel Masse would announce the order of a second unit at Point Lepreau at the Canadian Nuclear Association conference held in New Brunswick in June 1987, but no announcement was forthcoming. The government's position is that the project will not proceed without firm electricity purchase contracts from utilities in the northeastern USA.

The replacement of tubing at Ontario Hydro's first two Pickering units is nearing completion. Pickering Unit 1 reentered commercial service in November 1987, and Unit 2 is scheduled to restart in May 1988. Despite the lengthy shutdown of the two units due to the retubing, capacity factors for Ontario Hydro plants remained relatively high, averaging 70.6 percent for 1987, as compared to 80.9 percent lifetime capacity factor. Overall, capacity factors for Canadian nuclear units decreased slightly, from 72.8 percent in 1986 to 71.8 percent in 1987.

In March 1988, Ontario Hydro announced that it will advance plans to replace the pressure tubes in Pickering Units 3 and 4. Originally planned for the late 1990s, economic analysis indicated that the C$500 million project should commence in 1989 for Unit 3 and 1991 for Unit 4. Ontario Hydro expects the project to take slightly less than two years for each unit.

While the lack of firm electricity purchase contracts with US utilities has prevented the order of a second unit in New Brunswick, Hydro Quebec has recently been successful in selling electricity to the USA. In early 1987, the National Energy Board denied an application by Hydro Quebec for electricity exports, stating that Hydro Quebec had not adequately demonstrated that the power was, in fact, surplus. A second application was accepted by the Board in January 1988. The proposal provides for some 70 billion kilowatt-hours to be exported by Hydro Quebec to a group of New England utilities beginning in 1990. Ontario Hydro also is negotiating electricity sales to the USA.

Atomic Energy of Canada Limited (AECL) continued to explore the possibility of using low-enriched uranium in CANDU reactors, which currently use natural uranium oxide in the core. Studies have indicated that using uranium enriched to 0.9 to 1.2 weight-percent U_{235} could save as much as 25 percent on fuel costs by increasing burnup, as well as reducing the volume of spent fuel by as much as 50 percent. Nevertheless, one of the most attractive attributes of the CANDU design is its ability to operate on natural uranium, as Canada and most other nations operating CANDUs (Korea and India — Argentina is the exception) have no domestic enrichment capabilities. Thus, an attempt to introduce LEU to the CANDU design is likely to face some opposition from those who view the change as hampering export opportunities for AECL.

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CENTRAL AFRICA

Uranium producers in Gabon and Niger continued to enjoy a particularly attractive status from the standpoint of origin, especially to European buyers. Because of the continued sensitivity to the political ramifications of southern African-origin uranium purchases on the part of some buyers, in addition to the problems of using southern African material as feed for enrichment in the USSR, central African-origin uranium is considered highly usable, without restrictions on end use.

GABON

Uranium production in Gabon totaled approximately 2.1 million pounds U_3O_8, a slight decrease from the 1986 level. Uranium production in Gabon is owned by Comuf (Compagnie des Mines d'Uranium de Franceville), which operates the Oklo and Boyindzi mines and the 1,650 MTU capacity Mounana mill. Comuf is owned by a consortium consisting of Cogema (57.8 percent), Pechiney (13 percent), and the Gabonese government; the property is leased from France's CEA (Commissariat a l'Energie Atomique). Gabon's uranium production is largely captive to France; nearly 70 percent of the Mounana Mill's output goes to Cogema, with the remained going to European and Japanese buyers with short and medium-term contracts.

Exploration continues in Gabon, by several different groups. Comuf continued to explore in several areas; a group consisting of Cogema, the Gabonese government and the Korea Electric Power Corp. (KEPCO) conduct exploration operations as the Leyou-North Joint Venture; the Franceville-South Joint Venture is a consortium of Cogema, the Gabonese government, Urangesellschaft and Comuf. The government of Gabon encourages exploration by giving various exemptions and incentives in import duties and write-off s of expenditures to participating companies.

NIGER

The two uranium projects in Niger together produced approximately 7.8 million pounds U_3O_8 in 1987, a slight drop from the previous year. The state-owned mineral resources company Onarem (Office National des Ressources Minieres) maintains a subsidiary interest in both the Akouta mine and the Arlit project.

The Akouta mine is the world's largest underground uranium mine, and is owned by Cominak (Compagnie Miniere d'Akouta), a consortium consisting of Cogema (34 percent), Onarem (31 percent), Japan's Overseas Uranium Resources Development Company (25 percent), and Enusa, the Spanish fuel-cycle company (10 percent). The mine is operated by Cogema, which purchases about half of the mine's output.

The Arlit project is of the open-pit type, owned by Somair (Societe des Mines de l'Air). Somair is owned by Onarem (33 percent), Cogema (27 percent), Compagnie Francaise Mokta (a subsidiary of Cogema, 19.4 percent), Pechiney (7.6 percent) and Italy's Agip Uranio (6.5 percent). Cogema operates the project. 1987 production at Arlit was about 2.6 million pounds U_3O_8, well below its annual capacity of approximately 3.2 million pounds. Urangesellschaft and Agip Uranio retained their shares of ownership in Somair but have not purchased any of the project's output since 1984.

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EUROPE

Overview

Nuclear power stations generated over 652,000 Gigawatt-hours (GWh, gross) during 1987 in the eleven countries of western Europe having commercial programs, an increase of 2.8 percent over 1986 (Table 13). Four new units entered commercial operation, all of them in France. Construction programs in Spain and Germany should result in completion of five large units. Thereafter, France's Electricite de France (EdF) and the UK's CEGB (Central Electricity Generating Board) will be the only European utilities with active nuclear plant-building programs. CEGB is in the early stages of the Sizewell 'B' project, and EdF plans to add an average of two 1,300-MWe units per year over the next four years, and two 1,400-MWe units in the 1990s.

In France and Belgium, the two European countries with the most intensive per capita reliance on nuclear power, nuclear units accounted for 76 and 66 percent, respectively, of total national power production during 1987. Sweden's nuclear units accounted for 45 percent of total electricity generation in that country, where there was a large surplus of hydropower during the year. In Finland, Germany, Spain and Switzerland, the percentage was between 35 and 40 percent of the total, with notable growth in nuclear power's share during 1987 in Spain and Germany. As ranked by power generation, six of the world's ten best-performing units of 1987 were German stations built by Kraftwerk Union (KWU); two of the top three, Grohnde (1,300-MWe PWR) and Brokdorf (1,335-MWe PWR) are operated by the Hannover utility PreussenElektra AG.

With only a few exceptions, Nuexco is not aware of any significant long-term contracting activity for uranium concentrates, conversion services or enrichment services in Europe during 1987. Most utilities were adequately covered by inventory or contracts entered into in previous years. Those companies having near-term unfilled requirements purchased mainly on the spot market. The trend in Europe toward fuel optimization and recycling of uranium and plutonium had a noticeable effect on several utilities' fuel planning and will continue to influence purchasing activity in coming years.

Table 13

NUCLEAR POWER GENERATION IN WESTERN EUROPE IN 1987

Country	Number of Units (end 1987)	1986 Nuclear Generation (GWh Gross)[2]	1987 Nuclear Generation (GWh Gross)[2]	Percent Change 1986 to 1987	1987 Percent of Total Generated by Nuclear plants[3]
Belgium	7	38,635	41,927	+ 8.5	66
Finland	4	18,780	19,369	+3.1	37
France	53	254,216	265,484	+4.4	76
FR Germany	19	117,390	130,554	+11.2	37
Italy	3	8,651	174	- 98.0	n.a.
Netherlands	2	4,180	3,210	- 23.2	n.a.
Spain	8	37,463	41,222	+10.0	35[4]
Sweden	12	69,950	67,239	- 3.9	45
Switzerland	5	22,452	22,958	+2.3	38[4]
United Kingdom	23[1]	59,076	56,181	-4.9	16
Yugoslavia	1	4,019	4,495	+ 11.8	n.a.
Total	136	634,812	652,813	+2.8	

[1]Multiple-unit GCR stations were counted as one unit.
[2]Source: *Nucleonics Week*.
[3]Data from utilities in each country.
[4]Nuexco estimate.

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BELGIUM

Belgium's seven principal nuclear power units (Table 14) operated during 1987 at an impressive average capacity factor of 83 percent, and produced 66 percent of the electricity generated in Belgium during the year. All seven units are PWRs. The last units built in the country, Doel Unit 4 and Tihange Unit 3, entered commercial operation in 1985, and the government and utilities have for some time been considering construction of an eighth unit to be located at the Doel station (Figure 7). Due to the decline in public support for nuclear energy since the 1986 accident at Chernobyl, and a lack of current demand for additional generating capacity, no decision was taken on the proposed project during 1987.

The country's nuclear fuel supply company, Synatom, did not report any significant changes in its fuel situation during 1987. The company has long-term natural uranium contracts with producers in at least five supplier countries, including Australia, Canada and Niger. Its smallest supply arrangement is with the Belgian company Umipray, a producer of uranium as a by-product of phosphate operations in northern Africa. Most fuel processing is covered by contracts with European firms, including Synatom's 11.1-percent share in the Eurodif enrichment consortium. Synatom has purchased fuel in the spot market but is generally covered by its diverse contracts and a well-managed stockpile.

Table 14

NUCLEAR POWER STATIONS IN BELGIUM

Unit	Capacity (MWe Net)	Capacity Factor in 1987[1] (percent)	Total Electricity Generation in 1987[1]
Doel 1	392	85	3,075
Doel 2	392	76	2,755
Doel 3	900	74	6,059
Doel 4	980	79	7,221
Tihange 1	870	96	7,736
Tihange 2	900	83	6,858
Tihange 3	980	90	8,223
Total	5,415	*(avg.)* 83	41,927

[1]Source: *Nucleonics Week.*

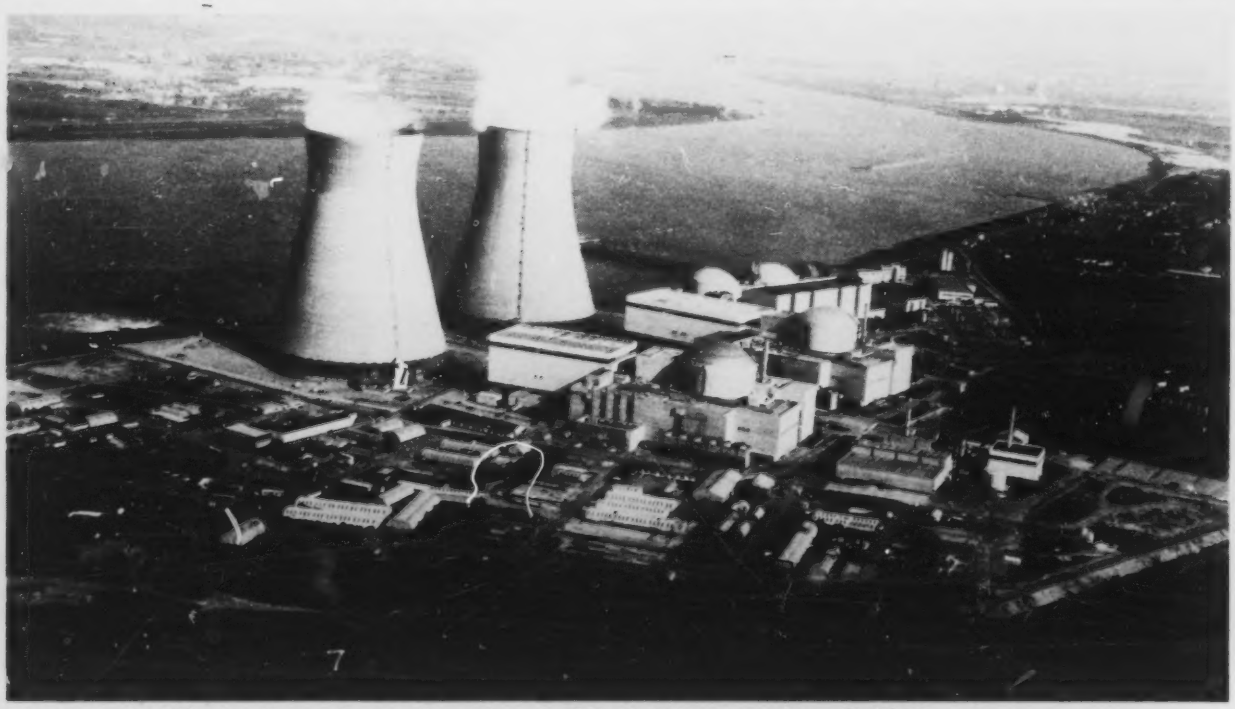

Figure 7. Doel Nuclear Power Station, located on the Schelde River in northern Belgium.

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FINLAND

Finland's four commercial nuclear power units generated 37 percent of the country's total electricity production during 1987, operating at an average capacity factor of 92 percent (Table 15).The country has four nuclear units at 2 stations; a pair of Swedish-built BWRs located at Olkiluoto on the southwest coast (Figure 8), and a pair of Soviet-supplied VVER-440 PWRs on the east coast. All four units have exceptionally good operating histories. The government of Finland has been debating construction of a fifth unit for several years, but due to declining public support for nuclear energy since the 1986 Chernobyl accident, and a lack of current demand for additional generating capacity, the government has not yet decided whether to proceed with the project. The utility TVO (Teollisuuden Voima Oy), operator of the BWRs, buys uranium from Canada and Australia and has enrichment contracts with the USSR. During 1987, TVO also signed a long-term uranium supply contract with the China Nuclear Energy Industry Corporation (CNEIC). All fuel requirements for the Soviet-built units are met by Soviet firms.

Table 15

1987 ELECTRICITY GENERATION IN FINLAND

Source	1987 Generation (GWh Net)	Percent of Total
Nuclear	18,549	37
Hydro	13,518	27
Back Pressure	13,287	26
Conventional	4,757	9
Other	586	1

Source: *Suomen Sahkolaitosyhdistys r.y.*

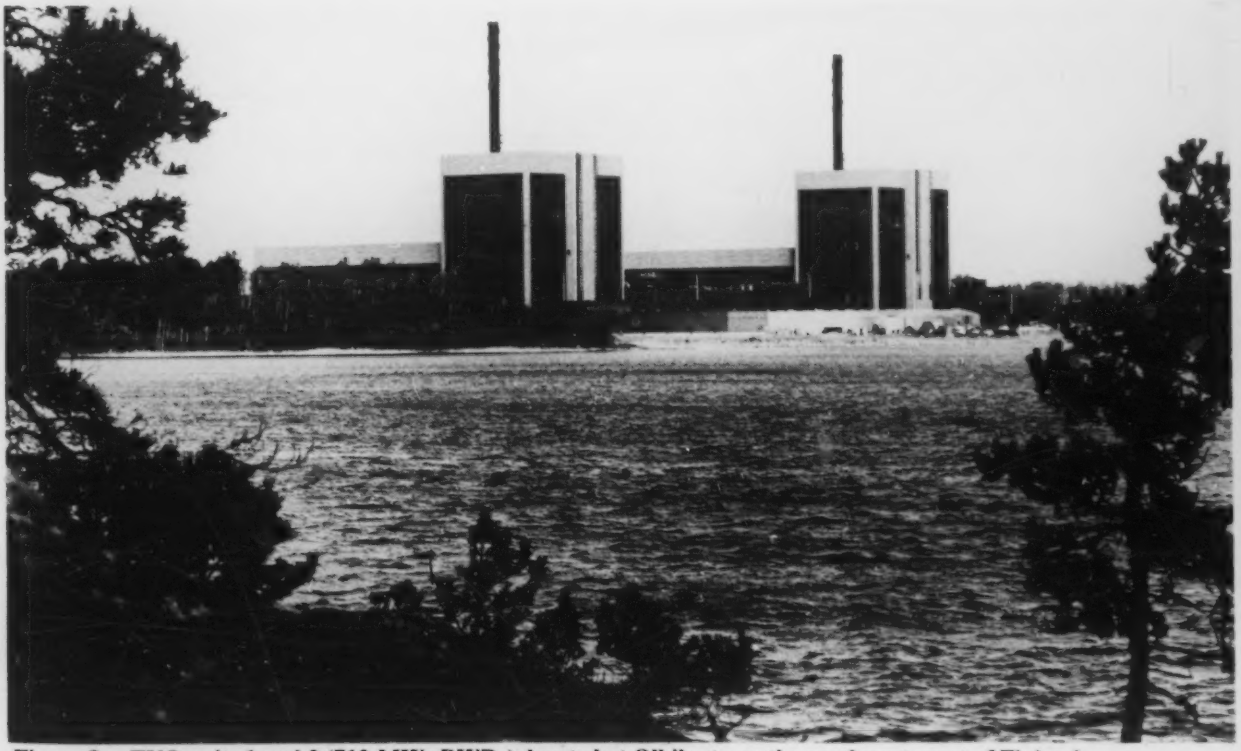

Figure 8. TVO units 1 and 2 (710-MWe BWRs), located at Olkiluoto on the southwest coast of Finland.

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FRANCE

During 1987, Electricite de France (EdF) commissioned the last unit of its 900-MWe PWR series, Chinon Unit B4, the thirty-fourth reactor of that size built in France since 1977. In addition, three units of the utility's 1,300-MWe series entered commercial operation: Cattenom Unit 2, Belleville Unit 1 and Nogent-sur-Seine Unit 1. EdF's 53 operating units (Table 17) accounted for 76 percent of national electricity production, the highest such share in the world. The utility has the lowest electricity rates in western Europe outside Scandinavia, and sold a net 29,800 GWh during 1987, approximately 9 percent of total electricity generation (Table 16). Figure 10 shows the locations of nuclear power stations and fuel cycle facilities in France.

EdF is the world's largest single consumer of nuclear fuel, with theoretical requirements during 1987 of approximately 20 million pounds U_3O_8 equivalent (8,000 MTU). The majority of natural uranium requirements are supplied by Cogema under long-term arrangements, with conversion at

Table 16

1986 FRENCH COMMERCIAL ELECTRICITY EXPORTS (GWh)

Country	Balance from Cross-Ownership in Nuclear Units	Balance from Direct Power Sales	Total Net Export Sales
Belgium	- 1,500	3,000	1,500
FRG	2,600	0	2,600
Italy	1,300	4,800	5,100
Monaco	0	200	200
Spain	- 800	2,400	1,600
Switzerland	3,200	3,600	6,800
UK	0	12,000	12,000
Total	3,800	26,000	29,800

* *Source*: EdF

Figure 9. Aerial view of the Eurodif enrichment plant (right) and the Tricastin Nuclear Power Station (left), adjacent to the Rhone River.

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Comurhex and enrichment at Eurodif. EdF also has natural uranium supply contracts with Total Compagnie Miniere of France, Queensland Mines Ltd. of Australia, and Malapai Resources of the USA, and receives additional enrichment from DOE and Techsnabexport (TSE). The utility made some uranium purchases on the spot market during 1987 due to high capacity utilization. Nuexco is not aware of any new long-term contracts negotiated during the year.

Nuexco estimates that French domestic uranium production from France's five mining regions amounted to over 8 million pounds U_3O_8 during 1987, covering about 40 percent of EdF's requirements. Cogema produced about 7 million pounds, with Total supplying the balance. Both Cogema and Total are active in uranium production and exploration abroad, and purchase uranium under long-term contracts from other suppliers. Total's principal mining project outside France is at Rhode Ranch in the USA, which it has developed together with Chevron Resources Corp. Cogema operates production facilities in Niger and Gabon, in the USA (Wyoming), and at Cluff Lake in Saskatchewan. In addition, it is the operating shareholder of the Cigar Lake project in Saskatchewan. Altogether, Cogema's uranium mining and exploration expenditures account for about 20 percent of the world total.

Figure 9 shows the Eurodif gaseous diffusion enrichment plant at Tricastin, with a nominal production capacity is 10.8 million SWU per year. Cogema is the marketing agent for Eurodif, and has sold about one million SWU per year to Japan and a smaller quantity to European and US utilities.

Cogema is the leading contractor for reprocessing services in the European market, supplying recycled uranium feed material, converted to UF_6 by Comurhex, and plutonium for mixed-oxide fuel assemblies. These activities are expected to increase significantly in coming years.

Mas Laveyre Open-pit Mine and Mill, Lodeve District, France.

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Table 17

NUCLEAR POWER STATIONS IN FRANCE

Unit	Capacity (MWe Net)	Type	COD[1]	Percent Complete	Capacity Factor in 1987[2] (percent)	Total Electricity Generation in 1987[2] (GWh)
Belleville 1	1,275	PWR	1987	100	28	717
Belleville 2*	1,275	PWR	1988	95	—	—
Blayais 1	910	PWR	1981	100	70	5,893
Blayais 2	910	PWR	1983	100	75	6,304
Blayais 3	910	PWR	1983	100	55	4,601
Blayais 4	910	PWR	1983	100	76	6,413
Bugey 1	540	GCR	1972	100	39	1,921
Bugey 2	920	PWR	1979	100	45	3,773
Bugey 3	920	PWR	1979	100	69	5,747
Bugey 4	900	PWR	1979	100	61	4,991
Bugey 5	900	PWR	1980	100	65	5,300
Cattenom 1	1,265	PWR	1986	100	67	7,941
Cattenom 2	1,265	PWR	1987	100	43	1,456
Cattenom 3*	1,265	PWR	1989	80	—	—
Cattenom 4*	1,265	PWR	1990	60	—	—
Chinon A3	360	GCR	1967	100	3	111
Chinon B1	870	PWR	1984	100	65	5,246
Chinon B2	870	PWR	1984	100	74	5,969
Chinon B3	870	PWR	1987	100	55	4,436
Chinon B4	870	PWR	1987	100	4	38
Chooz A[3]	305	PWR	1967	100	30	868
Chooz B1*	1,375	PWR	1992	45	—	—
Chooz B2*	1,375	PWR	1993	15	—	—
Cruas 1	880	PWR	1983	100	69	5,648
Cruas 2	880	PWR	1984	100	71	5,838
Cruas 3	880	PWR	1984	100	61	4,977
Cruas 4	880	PWR	1984	100	69	5,597
Dampierre 1	890	PWR	1980	100	61	5,073
Dampierre 2	890	PWR	1981	100	63	5,169
Dampierre 3	890	PWR	1981	100	65	5,354
Dampierre 4	890	PWR	1981	100	70	5,778
Fessenheim 1	880	PWR	1977	100	64	5,229
Fessenheim 2	880	PWR	1978	100	78	6,383
Flamanville 1	1,290	PWR	1985	100	64	7,495
Flamanville 2	1,290	PWR	1987	100	64	7,563

Note: Footnotes are on the next page

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Table 17 (continued)

NUCLEAR POWER STATIONS IN FRANCE

Unit	Capacity (MWe Net)	Type	COD[1]	Percent Complete	Capacity Factor in 1987[2] (percent)	Total Electricity Generation in 1987[2] (GWh)
Golfech 1*	1,275	PWR	1990	70	—	—
Golfech 2*	1,275	PWR	1993	40	—	—
Gravelines B1	910	PWR	1980	1	59	4,952
Gravelines B2	910	PWR	1980	100	67	5,639
Gravelines B3	910	PWR	1981	100	67	5,646
Gravelines B4	910	PWR	1981	100	68	5,741
Gravelines C5	910	PWR	1984	100	66	5,537
Gravelines C6	910	PWR	1985	100	70	5,883
Phenix	233	LMFBR	1973	100	77	1,680
Nogent sur Seine 1	1,275	PWR	1987	100	25	578
Nogent sur Seine 2*	1,275	PWR	1988	95	—	—
Paluel 1	1,290	PWR	1985	100	73	8,569
Paluel 2	1,290	PWR	1985	100	78	9,231
Paluel 3	1,290	PWR	1985	100	69	8,078
Paluel 4	1,290	PWR	1986	100	71	8,361
Penly 1*	1,290	PWR	1989	80	—	—
Penly 2*	1,290	PWR	1991	55	—	—
St Alban 1	1,300	PWR	1985	100	54	6,398
St Alban 2	1,300	PWR	1987	100	62	7,356
St. Laurent A1	390	GCR	1969	100	45	1,967
St. Laurent A2	450	GCR	1971	100	54	2,513
St. Laurent B1	880	PWR	1983	100	67	5,487
St. Laurent B2	880	PWR	1983	100	66	5,379
Superphenix[4]	1,200	LMFBR	1986	100	8	903
Tricastin 1	915	PWR	1980	100	75	6,259
Tricastin 2	915	PWR	1980	100	66	5,562
Tricastin 3	915	PWR	1981	100	71	5,911
Tricastin 4	915	PWR	1981	100	72	6,017
Total MWe	62,338			*(1987 Average)*	60	265,484

**Unit under construction.*

Source: EdF

[1]Actual or expected Commercial Operation Date.

[2]Source: *Nucleonics Week*.

[3]Chooz Unit A is owned and operated by SENA (Societe Nucleaire Franco-Belge des Ardennes), owned 50-percent each by EdF and the Belgian utilities.

[4]Superphenix is owned by NERSA, a European consortium of which the shareholders are EdF (51 percent), ENEL (33 percent), and SBK (16 percent). SBK is owned by RWE (FRG, 68.75 percent), SEP (Netherlands, 14.75 percent), Electronucleaire (Belgium, 16.5 percent) and CEGB (UK, 1.75 percent).

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Figure 10

NUCLEAR PLANT SITES AND URANIUM PRODUCTION CENTERS IN FRANCE

U_3O_8 Production Center
900-MWe PWR in Commercial Operation
1300-MWe PWR in Commercial Operation
GCR in Commercial Operation
FBR in Commercial Operation
GCR Undergoing Decommissioning
Nuclear Plant Site
Fuel Cycle Facility
900-MWe PWR Under Construction
1300-MWe PWR Under Construction

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FEDERAL REPUBLIC OF GERMANY

The outstanding operating performance of German nuclear units increased the contribution of nuclear energy to 37 percent of total electricity production during 1987, compared to 34 percent the previous year. The country's three largest units, Grohnde (1,300 net MWe), Philippsburg Unit 2 (1,268 MWe), and Brokdorf (1,335 MWe) produced more electricity during 1987 than any other nuclear units in the world. (Figure 12 shows the approximate share of nuclear-generated electricity among German utilities.) No new units entered commercial operation, although the Brokdorf plant operated for its first full year. RWE's Mulheim-Kaerlich station, commissioned in 1986 but shut down due to a legal challenge concerning the cooling tower, re-entered service in August 1987. Of the remaining three light-water reactors under construction at the end of the year, Isar Unit 2 entered commercial operation in February 1988, Emsland is expected to start up in April 1988, and GKN Unit 2 is expected to enter service in the fourth quarter of 1988. The Kalkar Fast Breeder Reactor remained indefinitely delayed throughout 1987 and there is little expectation that it will operate in the near future, if ever. Table 18 shows Germany's nuclear units in operation and under construction, and Figure 13 shows ownership of nuclear utilities and units in Germany.

Nuexco is not aware of any German utilities that signed new long-term contracts for uranium, conversion or enrichment during 1987. Three utilities did conclude spot purchases of natural uranium and two of enrichment services. The combination of high inventory levels, heavy long-term supply commitments and increased recycling of uranium and plutonium has considerably weakened the medium-term demand for uranium among most German utilities. For example, a substantial portion of the fuel requirements for PreussenElektra's Unterweser unit (Figure 11) were covered by recycled UF_6 (delivered as feed material to enrichment plants) and recovered plutonium (used in mixed-oxide fuel assemblies) during 1987.

The German companies Uranerz Bergbau (UEB), Urangesellschaft (UG) and Saarberg Interplan Uran (SIPU) delivered uranium to German utilities from overseas mining operations in which they are shareholders (Figure 14). UEB's subsidiary Uranerz Exploration and Mining is a one-third participant and the operator of the Key Lake project in Canada, which currently has the highest-grade reserves of any operating uranium mine in the world. UG

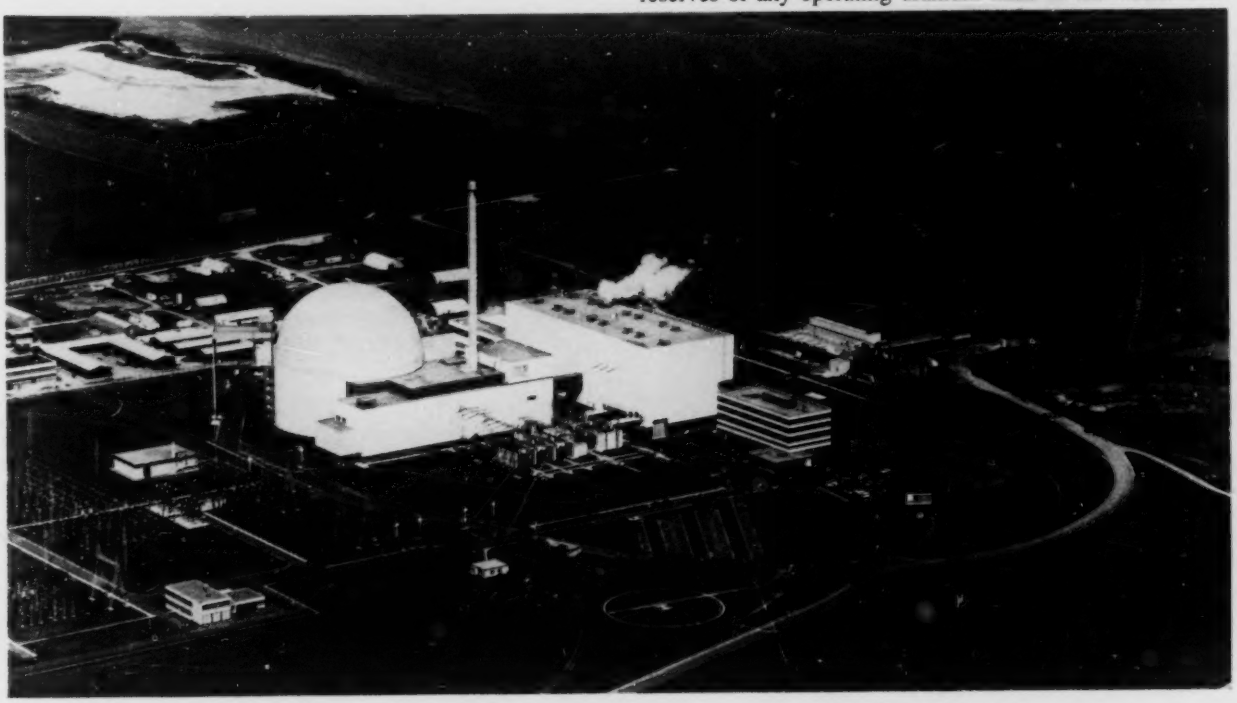

Figure 11. Unterweser Power Station (1,230 MWe), located near the mouth of the Weser River in Lower Saxony, northwest Germany.

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and SIPU own shares of Energy Resources of Australia. All three companies also participate in other exploration and mining ventures. Uranium production from two small mines in Germany amounted to just under 100,000 pounds U_3O_8 during 1987.

Conversion requirements are largely covered by Comurhex and BNFL (British Nuclear Fuels Ltd.) for German, Australian and African-origin uranium, and by Eldorado for Canadian-origin uranium. The majority of German utilities' enrichment requirements are filled by contracts with Urenco, the German-Dutch-British consortium operating a centrifuge plant at Gronau in Lower Saxony, with smaller amounts from Techsnabexport, DOE and Eurodif, in that order. Germany's two largest utilities, RWE (Rheinisch-Westfaelisches Electrizitaetswerk AG) and PreussenElektra, are indirect shareholders in Urenco.

The German utilities survived a difficult year politically in 1987, following the Chernobyl accident and elections in several states in which nuclear energy was a divisive issue. The excellent and safe operating records of the German nuclear stations has tended to counter public opposition. However, public controversy over nuclear power was again provoked late in 1987 by a bribery scandal and alleged nuclear transport infractions involving the company Nukem GmbH and its subsidiaries. Heavy press coverage of the incidents and the opening of criminal investigations has made conducting nuclear fuel cycle business in Germany more time-consuming and difficult. As of early 1988, there was considerable discussion about the creation of a centralized company in Germany, with responsibility for several aspects of the fuel cycle, although fuel procurement was not expected to be included in the scope of its activities.

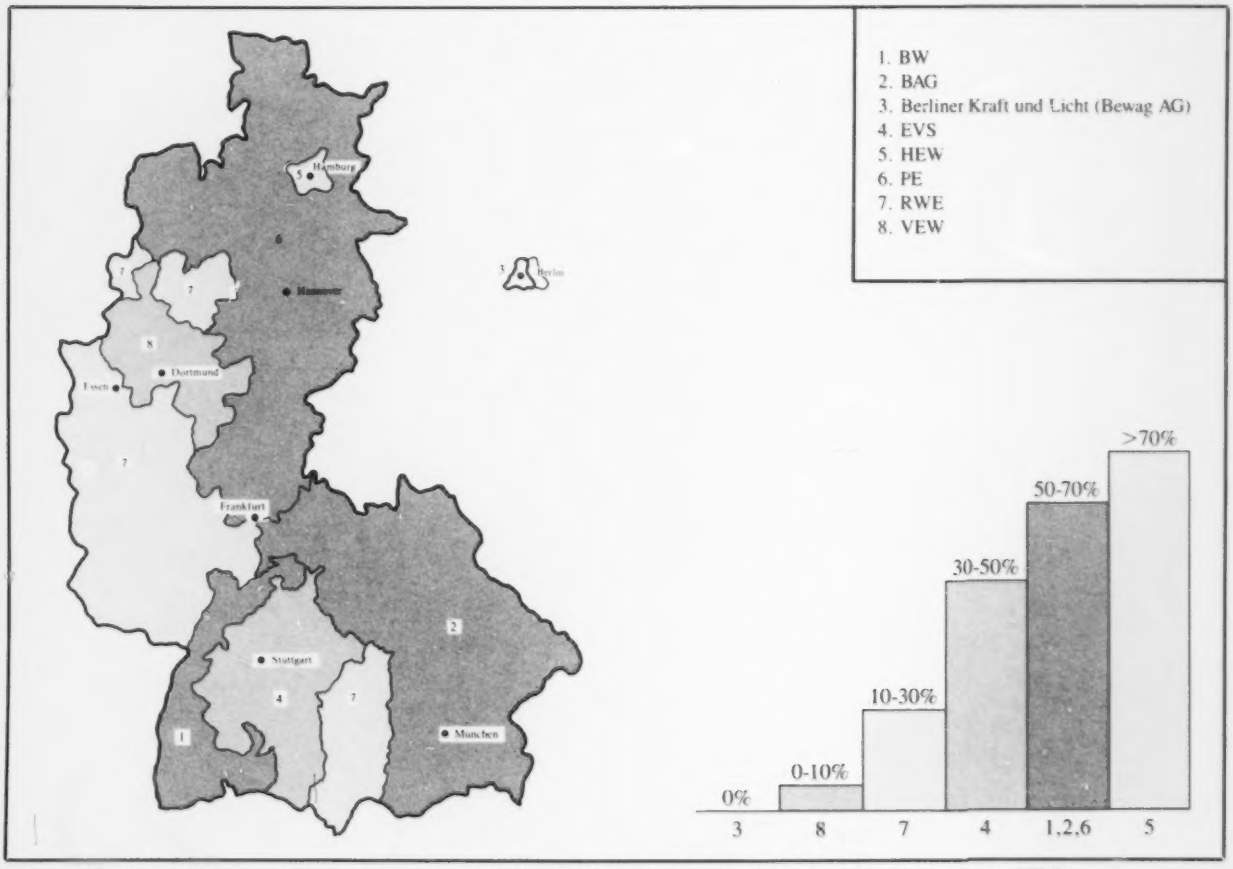

Figure 12. Actual Nuclear Energy share of principal utilities within the Federal Republic of Germany (FRG).

Source — Nuclear Europe

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Figure 13

NUCLEAR POWER PLANT OWNERSHIP IN THE FEDERAL REPUBLIC OF GERMANY

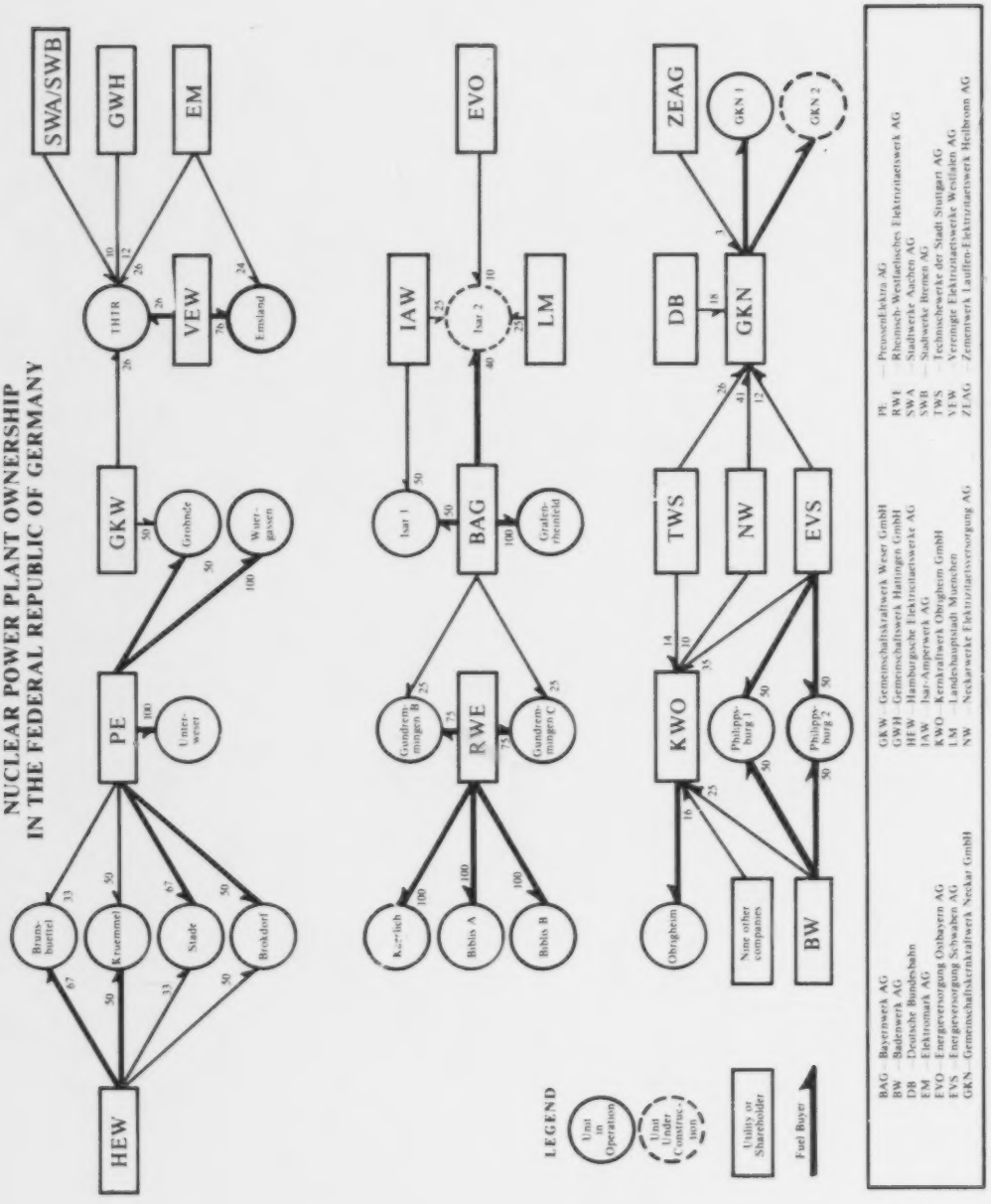

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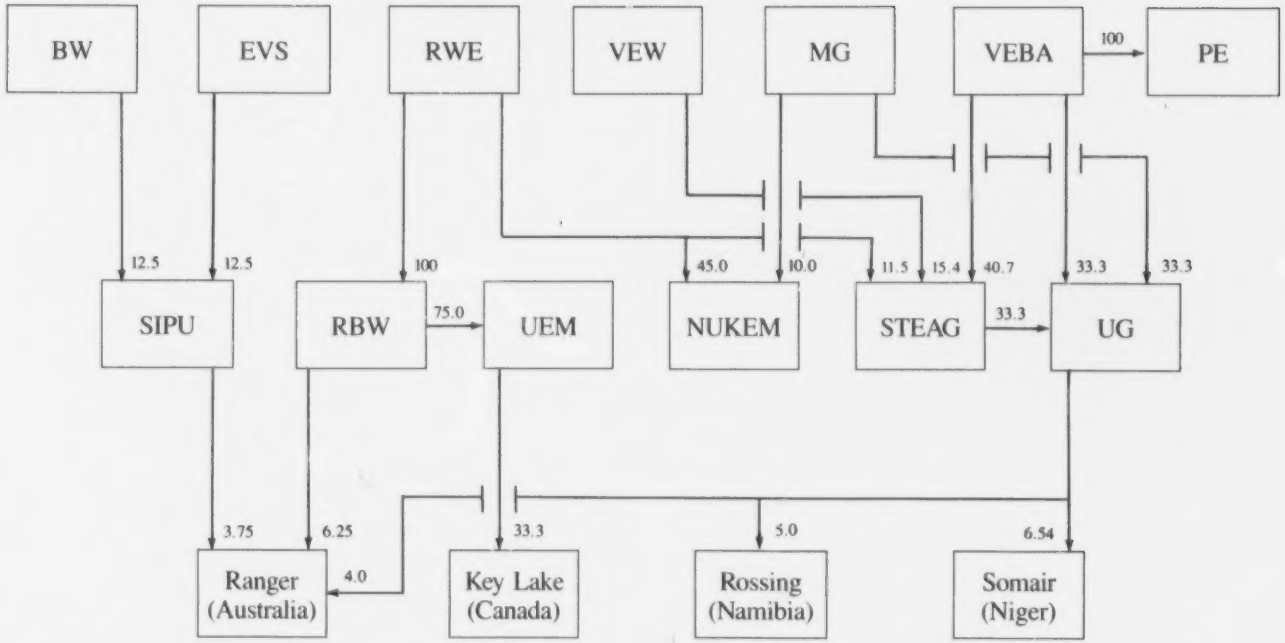
Figure 14

GERMAN OWNERSHIP IN ACTIVE URANIUM PRODUCTION AND TRADING OPERATIONS



BW	— Badenwerk AG	SIPU	— Saarberg Interplan Uran GmbH
EVS	— Energieversorgung Schwaben AG	STEAG	— Steag AG
MG	— Metallgesellschaft AG	UEM	— Uranerz Exploration & Mining Co.
NUKEM	— Nukem GmbH	UG	— Urangesellschaft mbH
PE	— PreussenElektra AG	VEBA	— Veba AG
RBW	— Rheinische Braunkohlenwerke AG	VEW	— Vereinigte Elektrizitaetswerk Westfalen AG
RWE	— Rheinisch-Westfaelisches Elektrizitaetswerk AG		

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Table 18

NUCLEAR POWER UNITS IN THE FEDERAL REPUBLIC OF GERMANY

Lead Utility and Fuel Buyer	Unit	Capacity (MWe Net)	Type	COD[1]	Percent Complete	1987 Capacity Factor in 1987[2] (percent)	Total Electricity Generation in 1987[2] (GWh)
BW/EVS	Phillippsburg 1	864	BWR	1980	100	86	6,755
	Phillipsburg 2	1,268	PWR	1985	100	85	10,084
BAG	Grafenrheinfeld	1,235	PWR	1982	100	78	8,864
	Isar 1	870	BWR	1979	100	94	7,464
	Isar 2*	1,227	PWR	1988	100	—	—
GKN	GKN 1	795	PWR	1976	100	77	5,747
	GKN 2*	1,230	PWR	1988	90	—	—
HEW	Brunsbuettel	771	BWR	1977	100	78	5,474
	Kruemmel	1,260	BWR	1984	100	83	9,572
KWO	Obrigheim 1	340	PWR	1969	100	83	2,607
PE	Wuergassen	640	BWR	1972	100	84	4,950
	Stade	640	PWR	1972	100	79	4,662
	Unterweser	1,230	PWR	1979	100	81	9,167
	Grohnde	1,300	PWR	1985	100	85	10,218
	Brokdorf	1,290	PWR	1986	100	82	9,975
RWE	Biblis A	1,146	PWR	1975	100	75	7,931
	Biblis B	1,240	PWR	1977	100	54	6,113
	Gundremmingen B	1,244	BWR	1984	100	77	8,861
	Gundremmingen C	1,244	BWR	1985	100	68	7,756
	Mulheim-Kaerlich	1,227	PWR	1986	100	29	3,168
SBK	Kalkar*	245	LMFBR	1987	95	—	—
VEW	THTR 300	296	HTR	1986	100	44	1,186
	Emsland	1,222	PWR	1988	100	—	—
Total		22,824			*(1987 Average)*	75	130,554

*Unit under construction.
[1]Actual or expected Commercial Operation Date.
[2]Source: *Nucleonics Week*.
BW = Badenwerk AG
BAG = Bayernwerk AG
EVS = Energieversorgung Schwaben AG
GKN = Gemeinschaftskernkraftwerk Neckar GmbH
HEW = Hamburgische Elektricitaetswerke AG
KWO = Kernkraftwerk Obrigheim GmbH
PE = Preussen Elektra AG
RWE = Rheinisch-Westfaelisches Elektrizitaetswerk AG
SBK = Schnell-Breuter Kernkraftwerksgesellschaft mbH
VEW = Vereinigte Electrizitaetswerke Westfalen AG

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ITALY

The Trino Vercellese unit (260-MWe PWR) was the only nuclear power station in Italy to operate during 1987, and only for a negligible period. Public opposition to nuclear energy after the Chernobyl accident in April 1986 led to the gradual shutdown of all three installed units. Following a public referendum on nuclear power in November 1987, the government ordered the permanent shutdown and decommissioning of Latina (150-MWe GCR), leaving only Trino and Caorso (875-MWe BWR) available for possible operation. The latter two units may be brought back into service during 1988 if an improved safety program can be demonstrated. The state utility ENEL currently is studying the possibility of converting the two-unit Montalto di Castro station (Figure 15), construction of which has been halted, to a gas-fired plant. All other nuclear power projects have been cancelled.

The cutback in ENEL's nuclear operations has led to a reduction of uranium demand. Although the company does not have any active uranium supply contracts, it has a significant stockpile and enrichment commitments to European suppliers. At the beginning of 1988, Agip Spa of Milan absorbed the activities of its subsidiary Agip Uranio (formerly Agip Nucleare) but did not announce any change concerning its participation in Eurodif.

NETHERLANDS

Both Borssele (477-MWe PWR) and Dodewaard (54-MWe BWR) operated well during 1987, as they have historically done. The Dutch government continued to defer its decision on construction of new nuclear power units despite evidence indicating a serious capacity shortage in the 1990s. PZEM (NV Provinciale Zeeuwse Energie Maatschappij), the owner of the Borssele station, made its last enrichment order to DOE during 1987. Beginning with the next reload, Urenco will cover 100 percent of PZEM's enrichment requirements. Urenco operates a centrifuge enrichment plant at Almelo, the Netherlands, in addition to a plant at Capernhurst, England and one at Gronau, FR Germany. PZEM has supplied all of its natural uranium requirements in recent years with spot market purchases. GKN (Gemeenschappelijke Kernenergiecentrale Nederland NV), the utility consortium operating Dodewaard, meets requirements from its stockpile, with enrichment from Urenco.

PORTUGAL

Nuexco estimates that production of U_3O_8 concentrate by ENU (Empresa Nacional de Uranio) at the Urgeiriça mill amounted to approximately 300,000 pounds U_3O_8 in 1987, about the same as in recent years. ENU has successfully marketed its material to European and US companies. No plans for substantial changes in ENU's production activities have been announced.

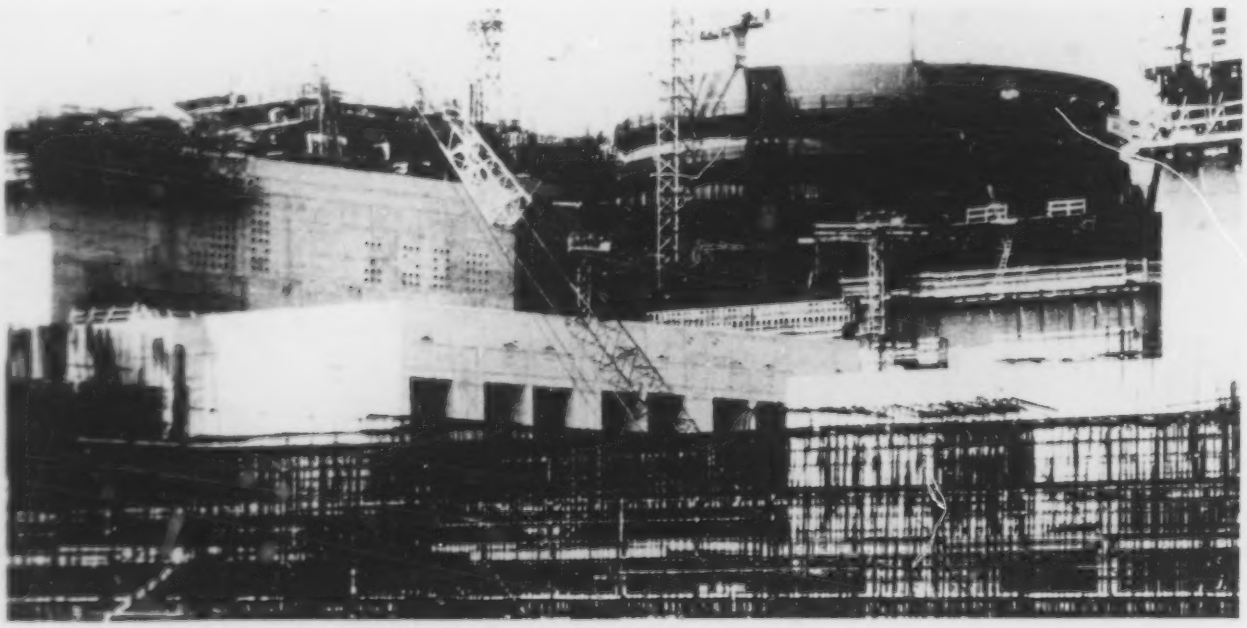

Figure 15. Construction underway at ENEL's two-unit Montalto station, currently being considered for conversion to a gas-fired plant.

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SPAIN

Spain's eight operating reactors contributed approximately 35 percent of domestic power production in 1987, at an average capacity factor of 80 percent. (Figure 16 shows the Cofrentes unit, a 975-MWe BWR, one of Spain's best-performing units.) The country's ninth commercial reactor, Vandellos Unit 2 (982-MWe PWR) reached criticality in the fourth quarter of 1987 and entered commercial operation early in 1988 (Table 19). Figure 17 shows the structure of utility ownership in Spain's nuclear units.

The last unit under construction under Spain's currently approved energy program, Trillo Unit 1 (997-MWe PWR), is scheduled for commercial operation in the first half of 1988 and should enable nuclear power's share of generation to equal that of coal, at about 40 percent of the total. In mid-1987, the Spanish government deferred a decision on additional nuclear plant construction until the end of 1988. Construction on the Lemoniz plants was virtually halted in 1984, when the government excluded the four units at those sites from the national energy plan. Lemoniz is widely presumed to be permanently cancelled, while Valdecaballeros Units 1 and 2 are expected to be completed under a future government.

The position of the Spanish nuclear fuel company Enusa (Empresa Nacional de Uranio SA) improved substantially during 1987. Enusa had encountered some financial difficulties as recently as 1985, due in part to a huge inventory and excessive supply commitments; the company has since managed to reschedule several of its supply arrangements. Its existing uranium contracts with two southern African producers and one Canadian producer are expected to end in the early 1990s. Thereafter Enusa will rely mainly on a 10-percent share in Cominak of Niger and on domestic production for its uranium supplies. The company is planning to build a conventional uranium mill near Ciudad Rodrigo, having a capacity of over 2.5 million pounds U_3O_8 per year in the 1990s, enabling a dramatic expansion

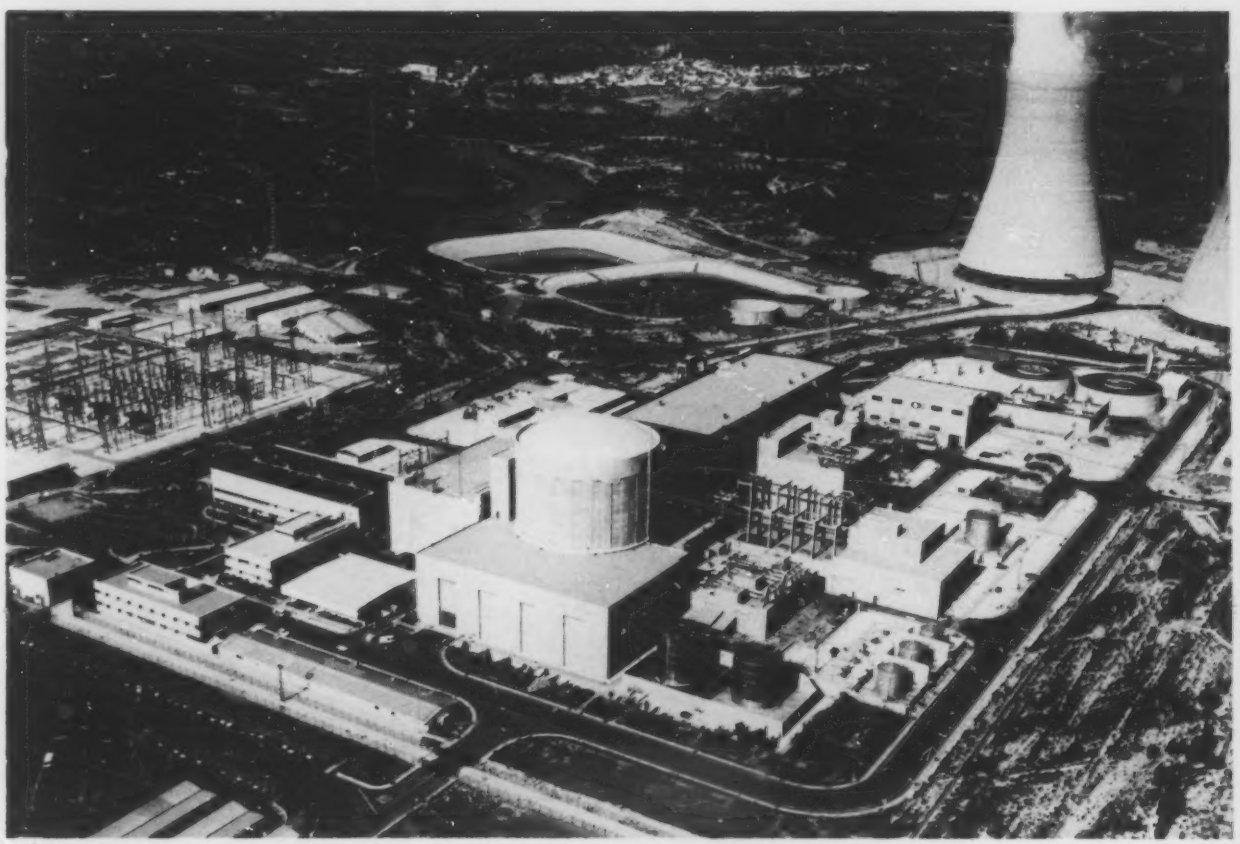

Figure 16. Cofrentes nuclear power station near Valencia in eastern Spain.

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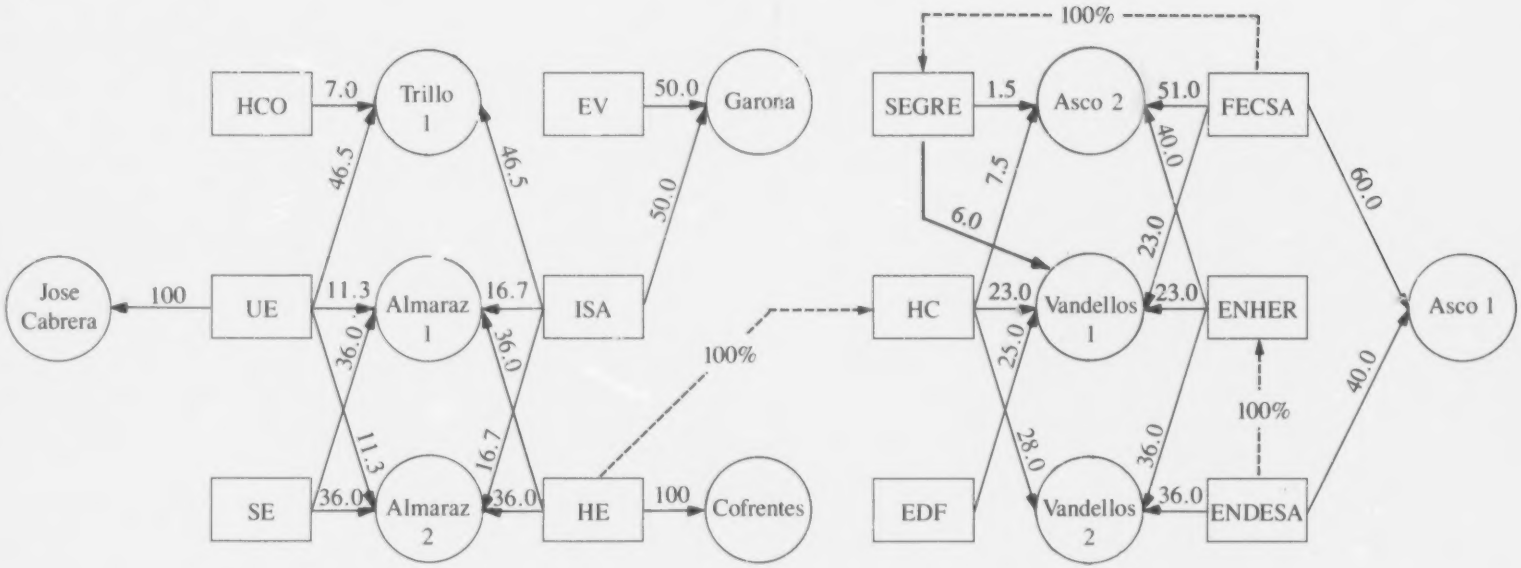
Figure 17

UTILITY OWNERSHIP OF NUCLEAR POWER UNITS IN SPAIN



EdF = Electricité de France.
ENDESA = Empresa Nacional de Electricidad SA
ENHER = Empresa Nacional Hidroelectrica Riborganza SA.
EV = Electricidad de Viesgo SA.
FECSA = Fuerzas Electricas de Cataluña SA.
HC = Hidroelectrica de Cataluña SA.
HCO = Hidroelectrica de Cantabrico SA.
HE = Hidroelectrica Española SA.
ISA = Iberduero SA.
SE = Compania Sevillana de Electricidad SA.
SEGRE = Fuerzas Electricas del Segre SA.
UE = Union Electrica-Fenosa SA.

Note: ENUSA is the fuel buyer for all Spanish units.

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of the current production operation. Currently, Spanish domestic production totals about 580,000 pounds U_3O_8 per year, most of which comes from low-cost heap-leaching around Ciudad Rodrigo (Figure 18). Reasonably Assured Uranium Resources (RAR) in Spain amount to 70 million pounds U_3O_8 at a cost of under US$30 per pound U_3O_8, making the country potentially the largest uranium producer in Europe outside France.

Enusa holds UF_6 conversion contracts with all of the European suppliers, as well as Sequoyah Fuels and Eldorado in North America. It also has enrichment supply arrangements with DOE, Techsnabexport and Eurodif, in which it is a shareholder. The company's domestic fuel fabrication plant at Juzbado has been producing fuel elements for PWRs and BWRs since August 1985, and processed 180 MTU in 1987. The Juzbado facility does not have UF_6-UO_2 conversion capability, however, and conversion of enriched uranium is performed by other western fabricators.

Figure 18. View of the FE uranium deposit 8 kilometers from Ciudad Rodrigo in western Spain, where expansion of mining and milling operations will substantially increase Spain's self-reliance in coming years.

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Table 19

NUCLEAR POWER UNITS IN SPAIN

Unit	Owners	Capacity (Net MWe)	Type	COD[1]	Percent Complete	1987 Capacity Factor in 1987[2] (percent)	Total Electricity Generation in 1987[2] (GWh)
Jose Cabrera[3]	UE	153	PWR	1969	100	83	1,160
Garona	ISA/EV	440	BWR	1971	100	67	2,696
Vandellos 1	Fecsa/Enher[4]/HC[5]/EdF	480	GCR	1972	100	72	3,135
Almaraz 1	UE/ISA/HE/SE	900	PWR	1981	100	92	7,525
Almaraz 2	UE/ISA/HE/SE	900	PWR	1983	100	82	6,662
Asco 1	Fecsa/Endesa	898	PWR	1984	100	82	6,667
Asco 2	Fecsa/Enher/HC/Segre[6]	898	PWR	1985	100	76	6,205
Cofrentes	HE	939	BWR	1985	100	84	7,172
Trillo 1	UE/ISA/HCO	997	PWR	1988	100	—	—
Vandellos 2[7]	Enher/HC/Endesa	982	PWR	1988	100	—	—
Total		7,587			*(1987 Average)*	80	41,222

[1]Actual or expected Commercial Operation Date.
[2]Source: *Nucleonics Week*.
[3]Also known as Zorita.
[4]Endesa purchased 100% of the capital of Enher in December 1985; Enher retains independent operations.
[5]HE purchased 100% of the capital of HC in December 1985; HC retains independent operations.
[6]Fecsa purchased 100% of the capital of Segre prior to December 1985; Segre retains independent operations.
[7]Vandellos Unit 2 was connected to the grid in December 1987. Commercial operation is expected in early 1988.

EdF = Electricite de France.
Endesa = Empresa Nacional de Electricidad SA.
Enher = Empresa Nacional Hidroelectrica Riborganza SA.
EV = Electricidad de Viesgo SA.
Fecsa = Fuerzas Electricas de Cataluna SA.
HC = Hidroelectrica de Cataluna SA.
HCO = Hidroelectrica de Cantabrico SA.
HE = Hidroelectrica Espanola SA.
ISA = Iberduero SA.
SE = Compania Sevillana de Electricidad SA.
Segre = Fuerzas Electricas del Segre SA.
UE = Union Electrica-Fenosa SA.

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SWEDEN

Nuclear power generation accounted for approximately 45 percent of Swedish electricity output in 1987, about the same as in 1986. The country relies on abundant hydropower resources for the balance of its electricity needs. The twelve operating nuclear units had an average capacity factor of 77 percent, led by Sydkraft's Barseback stations (Table 20). The current nuclear power program in Sweden was completed in 1985 with the commercial operation of Oskarshamn Unit 3 and Forsmark Unit 3; no additional units are planned. Figure 19 shows the Forsmark station.

None of the three Swedish utilities reported any new long-term contracts during 1987, although all were active in the spot market. For natural uranium the utilities are partly covered by existing long-term arrangements with Canadian and Australian producers. A combination of long-term contracts with DOE, Techsnabexport, Urenco and Eurodif supply most of the enrichment requirements. During 1987, the utilities exercised flexibilities in their supply contracts to take advantage of spot market opportunities, both in the uranium and enrichment markets.

Table 20

COMMERCIAL NUCLEAR PLANTS IN SWEDEN

Unit	Capacity (MWe)	1987 Capacity Factor[1] (percent)	Total Electricity Generation in 1987[1] (GWh)
Oskarshamn[2] 1	440	84	3,376
Oskarshamn 2	595	80	4,316
Oskarshamn 3	1,050	76	7,356
Barseback[3] 1	600	88	4,726
Barseback 2	585	88	4,641
Ringhals[4] 1	750	75	5,092
Ringhals 2	800	60	4,401
Ringhals 3	915	75	6,476
Ringhals 4	915	70	6,002
Forsmark[5] 1	970	77	6,774
Forsmark 2	970	77	6,778
Forsmark 3	1,050	76	7,301
Total	9,640	(avg.) 77	67,239

[1]Source: *Nucleonics Week*.
[2]Utility operator is OKG. Sydkraft AB owns 38 percent of OKG.
[3]Utility operator is Sydkraft AB.
[4]Utility operator is SSPB (Swedish State Power Board).
[5]Utility owner is FKA (Forsmark Kraftsgrupp AB). SSPB owns 74.5 percent of FKA and is the operator and fuel purchaser for the plant.

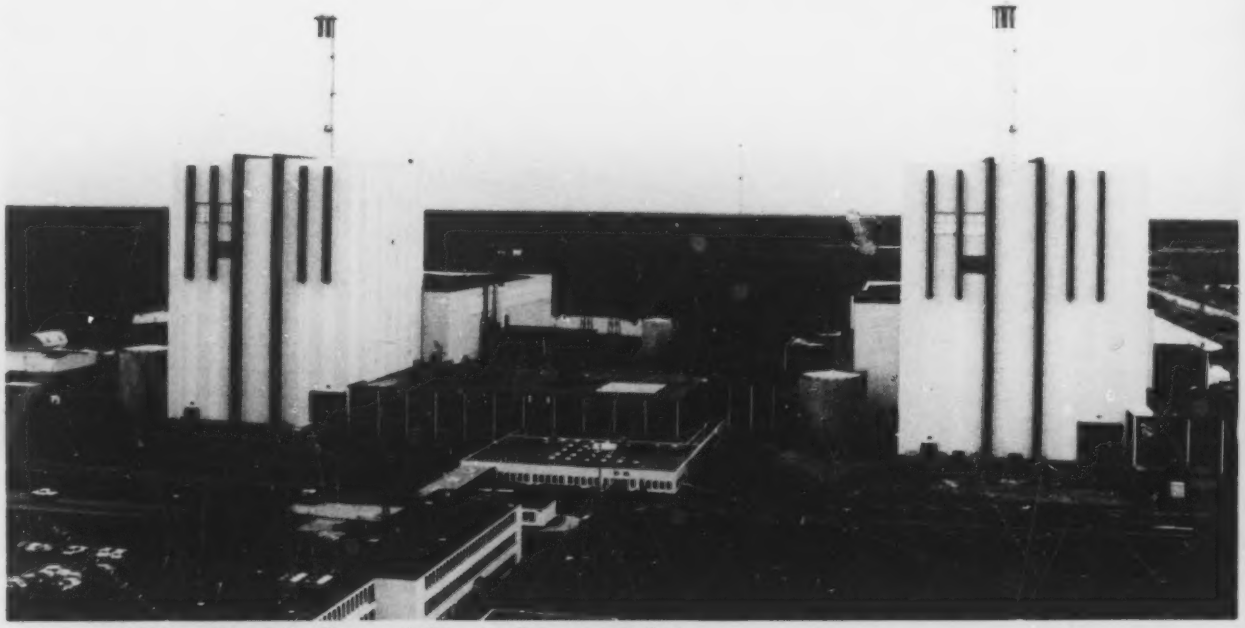

Figure 19. Two units of the three-unit Forsmark power station (2,850 MWe) operated by the Swedish State Power Board.

SWITZERLAND

The five Swiss nuclear power units performed well during 1987, with capacity factors of over 80 percent (Table 21). As in 1986, the nuclear units supplied about 38 percent of total electricity generation, with hydropower from the Alps providing the balance. Debate over future energy policy resulted in the continued deferral of future plant construction plans during 1987. Early in 1988 the government announced that it would prefer to cancel such plans, possibly signalling the end of the Kaiseraugst and Graben projects. The principal Swiss utilities have overcome the reluctance of the government to approve further increases in nuclear capacity by purchasing shares in the electricity production of French nuclear stations, notably Bugey, Fessenheim and Cattenom. During 1987, the Swiss share in Cattenom Units 3 and 4 was extended to a period of 25 years. In addition to investing in French plants, the utilities purchased substantial nuclear-generated electricity from EdF under seasonal contracts (see Table 16).

Each of the four Swiss nuclear utilities have substantial uranium inventories and none has actively sought material in the spot market for several years. Three of the four utilities have investments in mining projects in the USA that will yield substantial additional supplies in the future. Except for BKW (Bernische Kraftwerke AG), however, the companies' fuel cycle contracts are based in Europe. Two utilities have Eurodif enrichment contracts and one has a contract with Urenco.

Table 21

NUCLEAR POWER STATIONS IN SWITZERLAND

Unit	Capacity (MWe Net)	Capacity Factor in 1987[1] (percent)	Total Electricity Generation in 1987[1] (GWh)
Beznau 1[2]	350	81	2,594
Beznau 2	350	83	2,639
Muehleberg[3]	322	88	2,576
Goesgen[4]	909	86	7,315
Liebstadt[5]	955	86	7,834
Total	2,886	*(avg.)* 85	22,958

[1]Source: *Nucleonics Week*.
[2]Owned by Nordostschweizerische Kraftwerk AG (NOK).
[3]Owned by Bernische Kraftwerk AG (BKW).
[4]Owned by Kernkraftwerk Goesgen Daeniken AG (KKG).
[5]Owned by Kernkraftwerk Liebstadt AG (KKL).

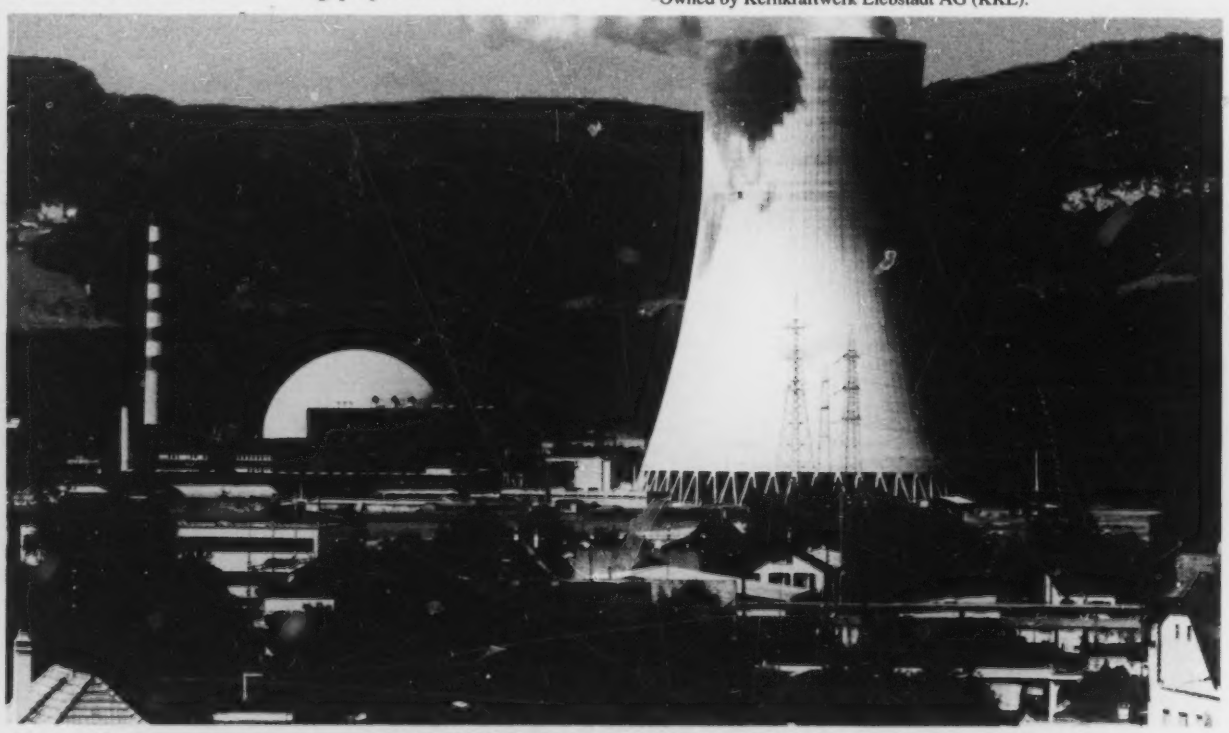

Figure 20. Goesgen nuclear power station (970-MWe PWR) on the Aare River in northern Switzerland.

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UNITED KINGDOM

After receiving formal approval to proceed with construction of the Sizewell 'B' PWR in March 1987, the CEGB (Central Electricity Generating Board) applied for authorization to build an identical unit at Hinkley Point. A public inquiry into the project has been scheduled for this year. With its experience from the lengthy Sizewell inquiry, it is possible that CEGB will receive the necessary authorization for the new unit by the end of 1988. The CEGB continues to experience problems in the commissioning of its AGR series, some of which have been in a "pre-commissioning" phase for the past several years. The average capacity factor of the CEGB's AGRs was less than 40 percent during 1987 (Table 22). Four new units are expected to achieve criticality during 1988 (two belonging to the South of Scotland Electricity Board), completing the AGR construction program. Figure 22 shows the location of nuclear power stations and fuel cycle facilities in the UK; Figure 21 shows the two-unit Wylfa GCR station in Wales.

The British Civil Uranium Procurement Organization (BCUPO) receives substantial deliveries from Canada annually, and during 1987 also took delivery of uranium from two US producers. Deliveries under BCUPO's large contract with Olympic Dam of Australia, signed in early 1987, are scheduled to begin this year. BCUPO conducts exploration activities in Canada, Australia, and the USA, and is involved in pilot mining projects in Germany and Malawi. UF_6 conversion requirements for UK plants are supplied by Eldorado and BNFL, while enrichment is supplied by Urenco, which is headquartered in Britain, and by Techsnabexport. BNFL is a major suppplier of UF_6 conversion services to European and Japanese utilities, as well as the fuel fabricator for the British reactors and the world's second largest provider of fuel reprocessing services, after Cogema of France.

YUGOSLAVIA

Yugoslavia's single operating nuclear power unit, a 664-MWe PWR located at Krsko, operated at 77 percent of capacity during 1987. The Krsko unit is important for the electricity supply of the two northern Yugoslav republics, Slovenia and Croatia. In mid-1986, a utility consortium accepted bids for the construction of an additional nuclear power unit in the northern part of the country, but as of the end of 1987, no decision to select a vendor had been taken. It currently appears doubtful that the utilities will proceed with an order, due to the difficult economic situation in Yugoslavia. A uranium mine at Ruzv near the Austrian and Italian borders produced approximately 250,000 pounds U_3O_8 in 1987, covering most of the domestic requirement. Enrichment has been performed entirely by DOE in recent years, with fuel fabrication by Westinghouse, the supplier of the Krsko plant.

Figure 21. Wylfa two-unit GCR nuclear power station in north Wales, the last of the first-generation Magnox stations built by CEGB.

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Figure 22

NUCLEAR POWER FACILITIES IN THE UNITED KINGDOM

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Table 22

COMMERCIAL NUCLEAR UNITS IN THE UNITED KINGDOM

Station/Unit	Capacity (MWe Net)	Type	Operating Entity	COD[1]	Percent Complete	Capacity Factor in 1987[2] (percent)	Total Electricity Generation in 1987[2] (GWh)
Calder Hall 1, 2, 3, 4	50 (ea.)	GCR	BNFL[3]	1956	100	79	1,662
Chapel Cross 1, 2, 3, 4	48 (ea.)	GCR	BNFL	1958	100	86	1,816
Berkeley 1, 2	138 (ea.)	GCR	CEGB[4]	1962	100	39	1,159
Bradwell 1, 2	123 (ea.)	GCR	CEGB	1962	100	66	2,197
Hunterston A1, 2	150 (ea.)	GCR	SSEB[5]	1964	100	87	2,624
Trawsfynydd 1, 2	195 (ea.)	GCR	CEGB	1965	100	70	3,655
Hinkley Point 1, 2	215 (ea.)	GCR	CEGB	1965	100	73	4,353
Dungeness A1, 2	212 (ea.)	GCR	CEGB	1965	100	61	3,173
Sizewell A1, 2	210 (ea.)	GCR	CEGB	1966	100	57	3,302
Oldbury 1, 2	217 (ea.)	GCR	CEGB	1968	100	59	3,344
Winfrith	92	HWLWR	UKAEA[6]	1968	100	64	563
Wylfa 1, 2	420 (ea.)	GCR	CEGB	1971	100	44	5,336
Dounreay	250	LMFBR	UKAEA	1976	100	42	916
Hunterston B1	575	AGR	SSEB	1976	100	60	3,562
Hunterston B2	575	AGR	SSEB	1977	100	85	5,044
Hinkley Point B1	520	AGR	CEGB	1976	100	35	2,061
Hinkley Point B2	520	AGR	CEGB	1977	100	55	3,236
Dungeness B1	450	AGR	CEGB	1984	100	5	291
Heysham A1	622	AGR	CEGB	1984	100	36	2,104
Heysham A2	622	AGR	CEGB	1985	100	41	2,417
Hartepool A1	626	AGR	CEGB	1984	100	8	447
Hartepool A2	626	AGR	CEGB	1985	100	33	1,967
Dungeness B2	600	AGR	CEGB	1986	100	16	950
Total MWe in Operation	10,230						
Heysham B1*	660	AGR	CEGB	1988	100	—	—
Heysham B2*	660	AGR	CEGB	1988	95	—	—
Torness Point 1*	660	AGR	SSEB	1988	100	—	—
Torness Point 2*	660	AGR	SSEB	1988	95	—	—
Sizewell B1*	1,100	PWR	CEGB	1995	0	—	—
TOTAL MWe	13.970				*(1987 Average)*	54	56,181

*Unit under construction

[1]Actual or expected Commercial Operation Date.

[2]Source: *Nucleonics Week*.

[3]BNFL = British Nuclear Fuels Ltd.

[4]CEGB = Central Electricity Generating Board.

[5]SSEB = South of Scotland Electricity Board.

[6]UKAEA = United Kingdom Atomic Energy Authority.

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JAPAN

By the end of 1987, Japan had 36 operating units at 15 commercial nuclear power plant sites (Figure 24). Total gross capacity is 28,046 MWe (Table 23). The total includes 16 PWRs, 18 BWRs, the Advanced Test Reactor (ATR) of the Power Reactor and Nuclear Fuel Development Corporation (PNC), and one Gas-Cooled Reactor (Tokai). Plant performance has increased steadily over the past several years, and 1987 capacity factors averaged 77.4 percent, compared to 76.2 percent in 1986.

In 1987, three new nuclear plants entered commercial operation in Japan, adding 3,300 MWe to the installed nuclear generating base. No additional plants are expected to enter commercial service until 1989. Figure 23 shows yearly additions to Japan's nuclear generating capacity. In February 1987, JAPC's Tsuruga-2 (1,160-MWe PWR) began commercial operation. Then, in August, Tepco's Fukushima II-4 (1,100-MWe BWR) went into operation, after being in trial operation since December 1986. With the commencement of operation of Fukushima II-4, the share of TEPCO's electricity generation capacity from nuclear plants stands at 25.5 percent. Also in August, Chubu EPC's Hamaoka unit 3 (1,100-MWe BWR) entered service. In addition, the utility obtained the construction license for Hamaoka Unit 4 (1,137-MWe BWR). At the end of 1987, Japan had 13 nuclear units under construction; 7 PWRs, 5 BWRs, and one FBR (Monju).

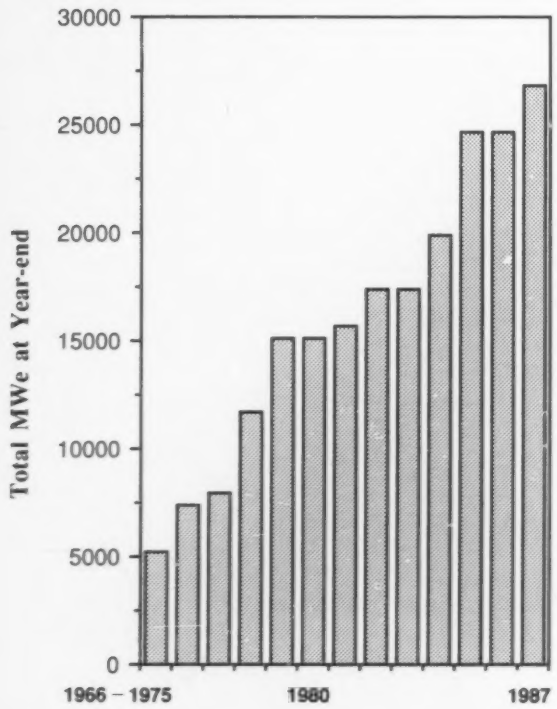

Figure 23

ANNUAL ADDITION OF NUCLEAR GENERATING CAPACITY IN JAPAN, 1966 to 1987

Not included in the tables are several nuclear plants that do not produce commercial electricity.

1. The PNC's Joyo FBR, which first began operation in 1979;

2. The Japan Power Demonstration Reactor at Tokai (JPDR),(12.5-MWe), a test BWR which was operated by JAERI from 1963 to 1969, when it ceased operation. It has been in the process of decommissioning since 1986.

3. The Science and Technology Agency's nuclear ship Mitsu, which will be undergoing functional testing throughout 1988 and 1989, aimed at beginning sea trials in 1990;

4. The Japan Material Test Reactor (JMT), a 10-MWt test reactor operated by JAERI. This unit was originally designed to test uranium-aluminum plates enriched to 93-percent U_{235}, but has been in operation testing fuel elements enriched to 45-percent.

Installed Capacity Forecast

In 1987, nuclear-generated electricity totaled 31.7 percent of Japan's total electric power generation, from 28,046 MWe end-of-year capacity. In June 1987, The Japan Atomic Energy Commission (AEC) approved a revision of Japan's Long-Term Nuclear Energy Development Plan, last revised in 1983. The Plan considerably lowers the earlier growth projection, from 62,000 MWe to 53,000 MWe installed nuclear capacity by the year 2000. This lowered figure still means that nuclear-generated electricity would grow to 25 percent of total installed electric generating capacity by the year 2000, more than doubling present capacity, and that nuclear power would account for about 40 percent of actual power generation. The difference in percentages between installed capacity and power generation is due to the projected use of nuclear as the primary base-load generator, while other sources would be more selectively used for load following and for peak demand.

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Table 23

NUCLEAR POWER PLANTS IN JAPAN
(including units in planning and under construction)

Utility	Unit	Capacity (MWe Net)	Type	Percent Complete[1]	COD[2]	1987 Capacity Factor[3] (percent)	Total Electricity Generation in 1987[3] (GWh)
Chubu EPC[4]	Hamaoka 1	515	BWR	100	Mar 1976	73	3,472
	Hamaoka 2	815	BWR	100	Nov 1978	99	7,258
	Hamaoka 3	1,066	BWR	100	Aug 1987	64	5,873
	Hamaoka 4[5]	1,045	BWR	0	Sept 1993	—	—
	Ashihama 1[6]	1,045	PWR	0	After 1995	—	—
	Ashihama 2[6]	1,045	PWR	0	After 1996	—	—
Chugoku EPC	Shimane 1	439	BWR	100	Mar 1974	78	3,159
	Shimane 2*	820	BWR	92	Feb 1989	—	—
	Toyokita 1[6]	1,100	LWR	0	After 1997	—	—
	Toyokita 2[6]	1,100	LWR	0	After 1999	—	—
EPDC[6]	Ohma[8]	570	ATR	0	After 1996	—	—
Hokkaido EPC	Tomari 1*	550	PWR	85	Jun 1989	—	—
	Tomari 2*	550	PWR	53	Jul 1991	—	—
Hokuriku EPC	Noto 1[5]	513	BWR	0	Mar 1993	—	—
JAPC	Tokai[9]	133	GCR	100	Jul 1966	59	856
	Tokai 2	1,056	BWR	100	Nov 1978	76	7,292
	Tsuruga 1	340	BWR	100	Mar 1970	79	2,464
	Tsuruga 2	1,115	PWR	100	Feb 1987	87	8,422
Kansai EPC	Mihama 1	320	PWR	100	Nov 1970	81	2,398
	Mihama 2	470	PWR	100	Jul 1972	67	2,927
	Mihama 3	780	PWR	100	Dec 1976	70	5,094
	Takahama 1	780	PWR	100	Nov 1974	69	4,975
	Takahama 2	780	PWR	100	Nov 1974	67	4,881
	Takahama 3	830	PWR	100	Nov 1974	82	6,264
	Takahama 4	830	PWR	100	Nov 1974	76	5,804
	Ohi 1	1,120	PWR	100	Mar 1979	95	9,794
	Ohi 2	1,120	PWR	100	Dec 1979	63	6,502
	Ohi 3*	1,121	PWR	13	Oct 1991	—	—
	Ohi 4*	1,121	PWR	1	Aug 1992	—	—
	Oura 1[8]	1,200	LWR	0	After 1995	—	—
	N1[7]	1,200	LWR	0	After 1996	—	—
Kyushu EPC	Genkai 1	529	PWR	100	Oct 1975	81	3,973
	Genkai 2	529	PWR	100	Mar 1981	83	4,077
	Genkai 3*	1,121	PWR	23	Jul 1993	—	—
	Genkai 4*	1,121	PWR	2	Jul 1995	—	—
	Sendai 1	846	PWR	100	Jul 1984	82	6,370
	Sendai 2	846	PWR	100	Nov 1985	81	6,326

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Note: Footnotes are on the next page.

Table 23

NUCLEAR POWER PLANTS IN JAPAN (cont.)

Utility	Unit	Capacity (MWe Net)	Type	Percent Complete[1]	COD[2]	1987 Capacity Factor[3] (percent)	Total Electricity Generation in 1987[3] (GWh)
PNC[10]	Fugen	148	ATR	100	Mar 1979	56	817
	Monju*	280	FBR	40	After 1991	—	—
Shikoku EPC	Ikata 1	538	PWR	100	Sep 1977	100	4,954
	Ikata 2	538	PWR	100	Mar 1982	80	3,964
	Ikata 3*	846	PWR	8	Mar 1992	—	—
Tohoku EPC	Onagawa 1	496	BWR	100	Jun 1984	73	3,343
	Onagawa 2[5]	784	BWR	0	Jul 1995	—	—
	Higashi Dori 1[6]	1,045	LWR	0	After 1997	—	—
	Namie Okada[6]	784	LWR	0	After 1998	—	—
	Maki 1[5]	784	BWR	0	After 1996	—	—
Tokyo EPC	Fukushima I-1	439	BWR	100	Mar 1971	87	3,487
	Fukushima I-2	760	BWR	100	Jul 1974	59	4,021
	Fukushima I-3	760	BWR	100	Mar 1976	56	3,835
	Fukushima I-4	760	BWR	100	Oct 1978	90	6,158
	Fukushima I-5	760	BWR	100	Apr 1978	61	4,167
	Fukushima I-6	1,067	BWR	100	Oct 1979	84	8,067
	Fukushima II-1	1,067	BWR	100	Apr 1982	76	7,305
	Fukushima II-2	1,067	BWR	100	Feb 1984	74	7,117
	Fukushima II-3	1,067	BWR	100	Jun 1985	81	7,775
	Fukushima II-4	1,067	BWR	100	Aug 1987	61	3,396
	Kashiwazaki-Kariwa 1	1,067	BWR	100	Sep 1985	100	9,594
	Kashiwazaki-Kariwa 2*	1,045	BWR	60	Oct 1990	—	—
	Kashiwazaki-Kariwa 3*	1,045	BWR	4	Jul 1993	—	—
	Kashiwazaki-Kariwa 4*	1,045	BWR	0	Jul 1994	—	—
	Kashiwazaki-Kariwa 5*	1,045	BWR	72	Apr 1990	—	—
	Kashiwazaki-Kariwa 6*	1,425	BWR	0	After 1995	—	—
	Kashiwazaki-Kariwa 7*	1,425	BWR	0	After 1998	—	—
Total In Operation		26,860			*(1987 Average)*	77	186,182
Total Under Construction		26,775					

*Unit under construction.
[1]According to published sources.
[2]Actual or expected Commercial Operation Date.
[3]Source: *Nucleonics Week*.
[4]EPC = Electric Power Company.
[5]Authorization for development planning granted by the Japanese Electric Power Development Coordination Council, but permission for reactor installation (construction start) was still pending as of September 30, 1987.
[6]Construction scheduled to start after Fiscal Year 1987; plan proposed by MITI in April 1987 (subject to approval).
[7]EPDC = Electric Power Development Company.
[8]Authorization for development planning still pending.
[9]Will be decommissioned after 1995.
[10]Power Reactor and Nuclear Fuel Development Corporation.

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Figure 24

NUCLEAR POWER PLANTS IN JAPAN

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The lower figures in this latest forecast, compared to that of the 1983 forecast, are the result of a decline in current and projected electricity demand, a more difficult social climate for nuclear growth in the aftermath of Chernobyl, and more fluid international trading patterns, such as potentially increased Japanese contracting for overseas coal.

The revised plan also calls for a delay to the commercialization schedule of fast breeder reactors (from 2010 in the earlier forecast to 2020-2030 now), although the emphasis remains the eventual shift to the FBR as the main plant type. Renewed stress is given to Japan's completion of a closed fuel cycle, relying heavily on reprocessing and domestic enrichment by the end of the century. The plan emphasizes the full development of Japanese nuclear technology, and calls for investment of $US 50 billion (7 trillion yen) in nuclear technology and international cooperation over the next thirteen years.

Cost Forecasts

The Japan Energy Economics Research Institute (JEERI) also has published a long-range forecast of nuclear power production costs, under a study requested by the Japan AEC. The report shows nuclear power continuing as the most economical power source in Japan, and predicts a decrease to 7.62 yen/ kwh by 2000, from the present 10.43 yen. By contrast, coal-fired plants' production is expected to cost 10.83 yen/kwh by the year 2000, compared to 11.63 for 1986. The forecast attributes nuclear's lower projected cost in 2000 to an assumed 15 percent lower construction cost for the upcoming advanced light water reactors (ALWR) compared to that of today's conventional reactor designs, and to presumed average capacity factors as high as 80 percent.

Fast Breeder Reactors

The revision of the Long-Range Nuclear Development and Utilization Plan has if anything reaffirmed Japan's commitment to pursue fast breeder commercialization, even while postponing the projected timetable by as much as two decades, to perhaps the year 2030. Part of the reason for the postponement is the stabilization of world uranium prices at under $30 per pound U_3O_8, which makes the plutonium-fueled FBR economically much less attractive. Japan's position of having to import virtually all its uranium, however, makes the FBR difficult to ignore, even if only as a contingency for the future. The long-range plan clearly anticipates a long period of stable, accessible uranium commerce.

Japan has two fast breeder projects at present, the experimental test reactor Joyo and the prototype 280-MWe FBR "Monju." Joyo first attained criticality in 1977; the Monju reactor is approximately 40-percent complete and is scheduled to begin operating in 1992, at a cost of more than double that of a light-water reactor. Work on the Monju project started in October 1985. Pressure and leak testing of the containment vessel were successfully completed in April 1987. The construction schedule calls for installation of the reactor's pressure vessel in the autumn of 1988, and completion of construction by 1991. Criticality is scheduled for mid-to late 1992.

Political Developments

In November 1987, Japan and the USA signed a new nuclear cooperation agreement. The 30-year agreement must first be reviewed by Congress in 90 days of continuous session, and enters into force after the 90-day period unless the Congress passes a joint resolution disapproving the agreement, then overrides a likely presidential veto. If Congress does not act within the proscribed time period, the agreement becomes effective. The Japanese Diet also conducts a review of the agreement. The new agreement replaces an earlier pact that would have expired in 2003. Under the accord, the US government grants Japan long-term or programmatic approval to reprocess US-controlled spent nuclear fuel, and to recycle the resulting plutonium in commercial nuclear reactors.

Although shipments have taken place for some time, approval has up to now been on a case-by-case basis. For example, in July 1984 the Reagan administration gave approval to ship 189 kg of fissile plutonium from France to Japan, but only under extremely high security that included use of US military personnel and satellite communications. That system did not allow what the Japanese considered to be an acceptable long-term planning basis, especially in light of Japan's increasing use of European reprocessing. By the mid-1990s, shipments of plutonium from Europe to Japan are forecast to rise to over 5,000 kg of Pu per year. Altogether, Japan is expected to take back about 48 MT of plutonium from European reprocessors in the 1990s.

As a condition for programmatic approval of the Pu shipments, however, the USA stipulated that all shipments to Japan from reprocessing facilities in Europe must take place by air, and fly polar air routes or other routes that avoid areas of civil disorder or natural disaster. One such

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flight pattern could require a refuelling stop in Alaska, a possibility that has provoked an angry response, and threat of lawsuits and other actions, from Alaska's governor Steve Cowper.

Fuel Cycle Facilities

Japan remains determined to complete its fuel cycle as rapidly as possible, including reprocessing of spent fuel, at first to be used in light water reactors and later to provide the basis for fuelling a fast breeder program. Japan's fuel cycle facilities are concentrated at Rokkasho-Mura, at the northern end of Japan's main island of Honshu. The site will cover approximately 6.5 square kilometers (2.6 square miles), and will cost over $4 billion when completed.

Enrichment

About half of the area of the Rokkasho-Mura facility is to be occupied by the enrichment enterprise. This facility is owned and operated by Japan Nuclear Fuel Industries (JNFI), which was organized in 1985 by a consortium of Japanese electric utilities and other nuclear industry companies. Phase one of construction, scheduled to begin in 1988, involves a 600,000 SWU per year enrichment plant, that will use gas centrifuge technology developed by the PNC. Phase 2 involves building a 900,000 SWU per year capacity addition to the plant, bringing its total capacity to 1.5 million SWU per year. The plant is scheduled to begin enriching material in 1991 from the initial 150,000 SWU per year production line, adding capacity in increments of about 100,000 SWU per year for about ten years. A second plant may also be built somewhere in western Japan, and will provide a capacity similar to the first full-scale plant, probably beginning in the mid-1990s. Even with half of the total demand contracted out to non-Japanese enrichers, Japan's domestic SWU requirements in the 1990s will exceed 6 million SWU per year.

Japan's enrichment program also includes a 50,000 SWU per year pilot enrichment plant designed and operated by the PNC, that began operation in 1979. The PNC also has built a demonstration enrichment plant, scheduled to begin operation in 1987, and producing 200,000 SWU per year by 1988. The first export of uranium for enrichment from the USA to Japan, involving over 60,000 kgs U_3O_8 equivalent of South African-origin UF_6, was sent to the demonstration plant for enrichment and later use in Kansai EPC's Takahama Unit 3.

Reprocessing

The Rokkasho-Mura site also includes a future reprocessing plant, primarily for LWR fuels, whose construction and operation is the responsibility of Japan Nuclear Fuel Services (JNFS), an organization formed by participants from the electric utility companies. The reprocessing unit will have a capacity of 800 tonnes per year spent fuel, and an adjacent spent fuel storage facility will be able to store 3,000 tonnes of spent fuel. The reprocessing plant was first scheduled to go into operation in 1995, but was rescheduled this year for December 1997. The storage facility was originally planned for 1991 operation, to allow for four years of spent fuel cooling before reprocessing, but it has now been postponed until March 1994.

The Japan Atomic Energy Commission (JAEC) also has begun implementing plans to build a 120 kg/day reprocessing plant to handle FBR spent fuel, scheduled to begin operation in about 1995. As Japan's FBR program grows, the plant's capacity will be gradually expanded to keep up with needs for FBR reprocessing. The PNC, which will be heavily involved in the project, has been conducting research and development in FBR reprocessing since 1975. In April 1987, JNFS signed an agreement for transfer of reprocessing technology from the French firm SGN (Societe Generale pour les Techniques Nouvelles). The agreement was under negotiation since December 1985. SGN was a logical choice for the Japanese; the French company had earlier supplied the technology for the Tokai demonstration plant. The technology being supplied by SGN is virtually the same as that being introduced at Cogema's UP2-800 and UP3 reprocessing plants at La Hague. The technology transfer agreement runs from April 30, 1987 for 12 years after the start of hot testing; fee for the transfer is reportedly 28 billion yen ($185 million). Further contracts involving equipment supply and engineering services could total an additional 50 billion yen ($330 million), several of which are likely to go to British Nuclear Fuels plc. (BNFL) for evaporator technology and to the German fuel cycle consortium DWK. In addition, SGN has awarded Mitsubishi Heavy Industries the contract, for about $130 million, for plant design.

A Plutonium Fuel Production Facility and associated Plutonium Contaminated Waste Facility has recently been completed at the Tokai site, with trial operation beginning in November 1987. The line is designed for FBR fuel production, and is rated at 5 tonnes per year capacity — sufficient for the 3.5 tonnes per year requirement of the Monju plant (scheduled for 1992 operation) and expandable to

meet the 10 tonnes per year needs of the Demonstration FBR, scheduled for later in the 1990s. The uranium-plutonium mixed-oxide (MOX) FBR fuel production line is the latest step in a FBR fuels research program that began in 1972 with a lab to supply MOX fuels to the Joyo FBR demonstration plant and the Fugen ATR.

Japan currently has contracts with BNFL and Cogema for reprocessing of approximately 5,000 tonnes of spent fuel, and plutonium from this source already is returning to Japan. The Long-Term Plan earlier mentioned projects spent fuel to reach 1,100 tonnes annually by 2000. The plan calls for a program of increasing use of MOX fuels in Japan's commercial reactors. This program would have 12 reactors using MOX assemblies in about one-third of their cores by 2000. As the projections for fast breeder commercialization were set back ten to twenty years in the Long-Term Plan, this period of trial use of MOX fuel elements in LWRs would presumably continue into the early 2000s, until the LWR's replacement by commercial fast breeder reactors. Already, test bundles of MOX fuel have been loaded into JAPC's Tsuruga-1 reactor (341-MWe BWR), and Kansai EPC's Mihama plant (320-MWe PWR) is slated to also receive MOX fuel elements. By about 1992, larger units, 800-MWe and above, will begin testing the MOX elements.

The PNC operates a 210-tonne-per-year demonstration plant at Tokai-Mura, which went into operation in 1977 and has reprocessed over 300 tonnes of spent fuel since it began operating.

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THE PEOPLE'S REPUBLIC OF CHINA

Introduction

The People's Republic of China has, since the 1950s, built a fairly extensive nuclear industry, incorporating a military reactor program, a number of research reactors and fuel-cycle facilities, and development of domestic uranium resources. The Institute of Atomic Energy in Beijing operates a 10-MWth research reactor, a 3.5 MWe pool-type reactor and a 12-MWe heavy water reactor, upgraded from its original 7 MWe. Shanghai's Atomic Energy Research Institute, which conducts research into reactor design, in 1984 commissioned a 27-MWe PWR. Currently, a 5-MWth water-heating reactor is being built by the Institute of Nuclear Technology at Qinghua University, combining technologies from the FRG and the USSR. In 1980, the Southwest Institute of Reactor Design Engineering at Jiajiang, in Sichuan province, commissioned China's largest research reactor, a 125-MWe high-flux unit. Shortly after this unit began operating, Premier Li Peng noted that it was the tenth indigenous research reactor to be commissioned in China.

China currently has three commercial PWRs under construction — a twin-unit (2 x 960-MWe) station at Daya Bay near Hong Kong and Guangzhou, and a single 300-MWe unit at Qinshan, near Shanghai. The Daya Bay station is being built by a consortium headed by Framatome and Electricite de France (EdF) and is based on current French PWR technology. The plant at Qinshan is a domestic design, built mainly with Chinese-manufactured equipment.

China's International Nuclear Agreements

In nuclear technology and trade, China's relationships with other countries gradually have extended to the point where relatively normal commerce is able to take place. China has entered into bilateral nuclear cooperation agreements with many countries, including Argentina, Belgium, Brazil, the Federal Republic of Germany, Finland, France, Italy, Japan, Pakistan, Switzerland, the United Kingdom and the USA.

Several agreements were signed in 1987, opening the way for increased nuclear-related commercial activity between western countries and China in the future.

Finland — In July 1987, the governments of China and Finland signed a nuclear cooperation agreement, that would promote closer ties between the two countries. The agreement came in conjunction with a long-term uranium sale by China to TVO (Teollisuuden Voima Oy), a Finnish utility, to supply 600 MT of uranium between 1988 and 1995, about 30 percent of TVO's requirements in that period.

Federal Republic of Germany — KWU continues to maintain a presence in China, and is actively participating in a feasibility study to determine what type and size, if any, may be appropriate for additional units to be added to the Qinshan site. In August 1987, Chancellor Helmut Kohl visited China, and while no formal agreement was signed, the visit prompted the Chinese government to state officially its intention to continue the two countries' ongoing bilateral cooperation. This cooperation has largely been carried out under the auspices of Kraftwerk Union.

Switzerland - In November 1986, the government of Switzerland signed a bilateral nuclear cooperation agreement, followed in May 1987 by the Swiss Federal Executive Council's recommendation that Parliament ratify the agreement. Under the proposed pact, Swiss utilities will be able to buy uranium directly from China, and Swiss industry can more easily supply services, equipment, and technology to China. The accord also lets Switzerland pursue the possibility of sending spent fuel and vitrified high-level waste to China for storage, reprocessing or permanent disposal.

USA — An agreement was first signed in July 1985 between the USA and the PRC, and on December 31, 1985, a 30-year US-China nuclear cooperation agreement took effect, after an exchange of notes by US and Chinese government officials in Beijing. Under the agreement, the State Department gave the NRC authorization to proceed with issuance of all pending licenses for transfer of nuclear-related technology to China.

The full text of the arrangements finally was negotiated in June 1987, and has since been undergoing interagency review. Finalization requires that President Reagan certify to Congress that the arrangements of the cooperation agreement will ensure that exports of US equipment are used for peaceful purposes. Before any exports can be licensed, the certification must be before Congress for 30 days of continuous session.

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Current Nuclear Projects

Qinshan — Located 92 km from Hangzhou and 126 km southwest of Shanghai (Figure 25), the Qinshan project had its start in 1972, when Premier Zhou Enlai first approved funds for its development. Civil construction began in March 1984, requiring removal of over one million cubic meters of rock and soil in order to begin construction of the main buildings. Construction of the main reactor buildings started in January 1985, and the 7.5 m-thick concrete foundation mat was completed by June. The civil works were basically completed by mid-1987. Participation by foreign firms in the Qinshan project is expected to total from 20 to 30 percent of the $300-400 million total project cost. By mid-1987, over 70 percent of the internal reactor parts, and over 50 percent of all major components had reportedly been completed; the entire Qinshan project is said to be approximately two-thirds finished. The official schedule now calls for completion by 1990.

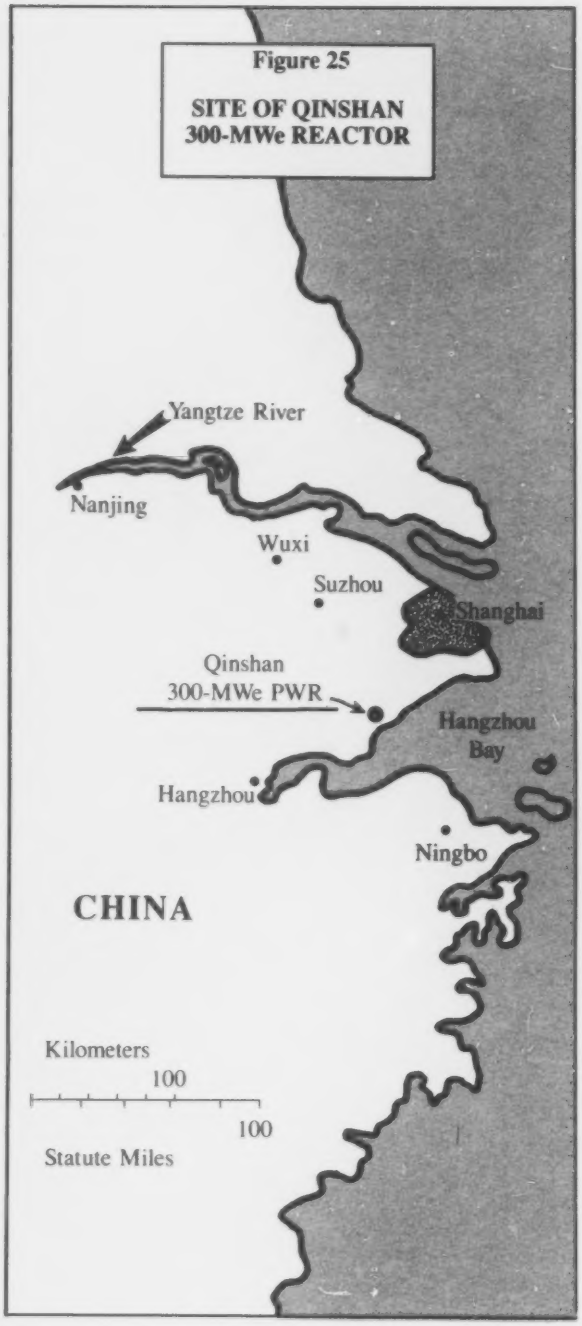
Daya Bay — The owner of the twin-unit, 960-MWe PWR plant, near Guangzhou (Canton) and Hong Kong (Figure 26), is Guangdong Nuclear Power Joint Venture Company (GNPJVC), which is a joint venture of China Light & Power Company of Hong Kong (25-percent) and Guangdong Nuclear Power Company (75-percent). Under the venture's agreement, the Hong Kong partner will have the option to take up to 70 percent of the units' electricity when the plants go into operation in the early to mid-1990s.

EdF's contribution includes acting as consultant to GNPJVC, in various levels of project management, participating in negotiations concerning the civil contracting and contracts for various equipment items that are not covered under the contracts to the main suppliers, Framatome and GEC. EdF's responsibilities also include overall engineering for the project, engineering studies for much of the station buildings, excluding the turbine building, and advising on operating procedures.

The primary civil construction is being performed by a joint-venture of several organizations. China's Huaxing Nuclear Industry Construction Company and the Second Bureau of China State Construction Engineering Company have been awarded contracts for 50 percent and 5 percent of the civil work, respectively. France's Campenon Bernard and Japan's Maeda Construction Company have 35 percent and 10 percent interests, respectively. Campenon Bernard

Figure 25

SITE OF QINSHAN 300-MWe REACTOR



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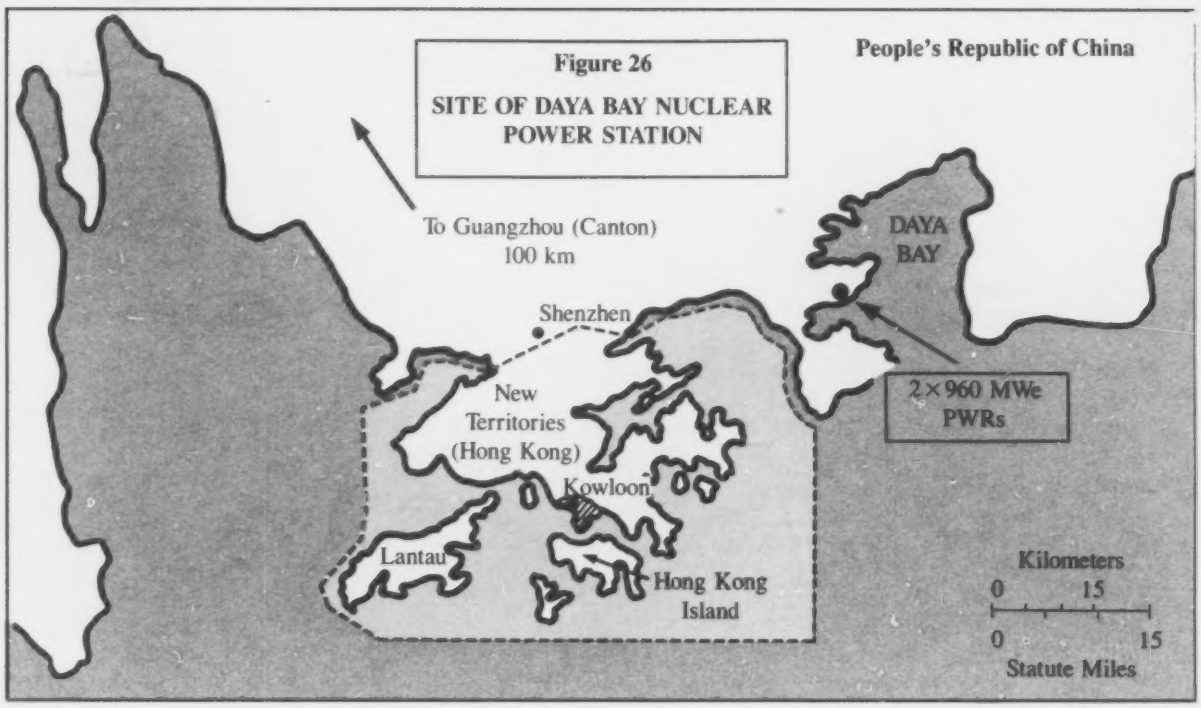

is the technical leader for the nuclear island construction, while Maeda is technical leader for balance-of-plant construction. The civil engineering portion of the project is valued at about $224 million, and will include the reactor and fuel storage buildings, as well as other facilities.

China's Nuclear Planning

In July 1987, China and the FRG officially decided to continue with bilateral nuclear cooperation, during a visit to China by Chancellor Helmut Kohl. The decision had been helped by KWU's participation, even after the Chinese decision to pursue an indigenous-only program, in a joint feasibility study with China's Ministry of Nuclear Industry to explore ways to develop a 600-MWe reactor loosely based on the Qinshan design.

Accordingly, since Kohl's visit there have been some indications that the indigenous-only policy could be modified to once again include foreign assistance for additional reactors at the Qinshan site. Although China has not actually committed itself, the key to the plan's success probably lies in the type of arrangements that can be made to pay for the foreign participation in the plants.

Negotiations, evidently carried out over a lengthy period of time and at a high political level between the Chinese and West German governments as well as representatives of KWU and several German utilities, have once again centered around a multi-faceted countertrade arrangement involving reactor design and equipment supply, purchases of Chinese uranium by German utilities, and possible storage or reprocessing in China of German utilities' spent fuel. This would likely include a high degree of Chinese manufacturing involvement in any reactor construction, considerable technology transfer to China, as well as competitive pricing of Chinese uranium.

Thus, although the role of KWU and the FRG in China's nuclear planning appears to be unofficial as yet, the current plan now appears to be focusing on development of a domestic manufacturing base for the 300-MWe PWR design such as is found at Qinshan, with some outside design and manufacturing assistance in upgrading to 600-MWe. China clearly intends to eventually produce indigenously the types of equipment that currently are being imported for Qinshan, as soon as domestic facilities can attain the technical levels required; technology licensing will be preferred over out-of-country manufacture.

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At present, Chinese energy plans appear to accept in principle the construction of up to four additional 600-MWe PWR units at the Qinshan site. The 300-MWe reactor under construction is now officially scheduled for trial operation in 1990, and probably will not start commercial operation before the early 1990s. The site will then be open for additional construction. However, it seems perhaps too ambitious for four more units to be completed at that site by 2000, and under the most optimistic scenario, China would not have more than 4,500 MWe of nuclear capacity, including Daya Bay, by the year 2000.

Other Planning and Research

It is possible that China will proceed with plans to build at least one, and possibly two medium-sized reactors for district heating. Two northern cities, Harbin and Shenyang, have included proposals for such reactors in their development plans. Qinghua University in Beijing has for some time been actively developing a 5-MWth prototype heating reactor (a modified BWR, using 3-percent enriched uranium fuel), and reportedly is set to install such a unit 60 km northwest of Beijing, providing heating for 70,000 m^2 of building area. Active research and planning also is underway at Harbin to determine the requirements for building a 450-MWth, low-temperature district heating reactor. Such a unit would supply heat to a ten million m^2 building complex, saving 600,000 tons of coal per year, and also could possibly operate in conjunction with the Yilin coal gasification project at Harbin.

Uranium Resources

China began exploring for uranium in the 1950s, with the assistance of geologists from the USSR. Mining and milling of uranium has been carried out since 1962, primarily for military purposes, and the country is thought to have a large stockpile of material, primarily in the form of UO_2. Chinese officials have stated on numerous occasions that China could easily run at least fifteen 1,000-MWe reactors for 30 years using domestic resources, and western observers have estimated that China's economically exploitable reserves could total a minimum of 260 million pounds U_3O_8 (100,000 MTU), with total known reserves as high as 2 billion pounds. If speculative reserves are included, the figure could be as high as 8 billion pounds U_3O_8 (3 million MTU).

Uranium deposits are known to occur in many provinces, but are concentrated in the northern and southeastern parts of the country. In the southern part of China, significant deposits exist in Yunnan, Guangxi, Guangdong, Hunan and Jiangxi provinces (See Figure 27). Most Chinese uranium mines are of the underground type, using cut-and-fill methods and tracked machinery. The Chinese also produce uranium from several by-product or co-product operations, including recovering uranium from molybdenum and molybdenum-rhodium ores, and from uranium-bearing coal.

In 1987, it was reported that China had completed work on its largest uranium-producing complex to date, the Wuzhou mine and mill located in eastern Jiangxi province. Uranium deposits in this area have been mined on a relatively small scale since discoveries were made in the early 1960s. According to press reports, the new mine covers 300 km^2 and has reserves adequate for 100 years of mining. Its expected production figures were not disclosed.

Almost the only uranium production facility visited by westerners is the mill at Hengyang, in Hunan province south of the provincial capital of Changsha. Ore for the mill comes from a number of nearby mines, and is of several different types, including sandstones, slate, shale, and volcanic rocks. The Hengyang mill, with a capacity of over 1,000 MTU per year, has been designated for export production, although should export commitments become greater than Hengyang's capacity can handle, other mills and mines also may produce concentrates for export.

Uranium Marketing

The China Nuclear Energy Industry Corporation (CNEIC), affiliated with the Ministry of Nuclear Industry, is in charge of marketing China's uranium outside of China. The first uranium exports were made to PNC of Japan, in small amounts of 30 to 40 MTU for each of several deliveries. In 1985 and 1986, CNEIC signed uranium supply contracts with the German utility Gemeinschaftskernkraftwerk Neckar (GKN) and France's EdF. If maximum quantity options are chosen, the average combined deliveries to the two utilities could reach over 300 MTU per year beginning in 1988. In 1987, CNEIC and the Finnish utility TVO signed an agreement under which China will supply TVO with about 1.6 million pounds U_3O_8 (600 MTU) over the period 1988 to 1995, a contract worth about US$ 35 million. China has stated that it wishes to gradually increase its uranium exports to about 2.6 million pounds U_3O_8 per year (1,000 MTU) by 1995, either as concentrates or as UF_6. CNEIC also has expressed some interest in selling on the spot market, but clearly prefers long-term contracting arrangements.

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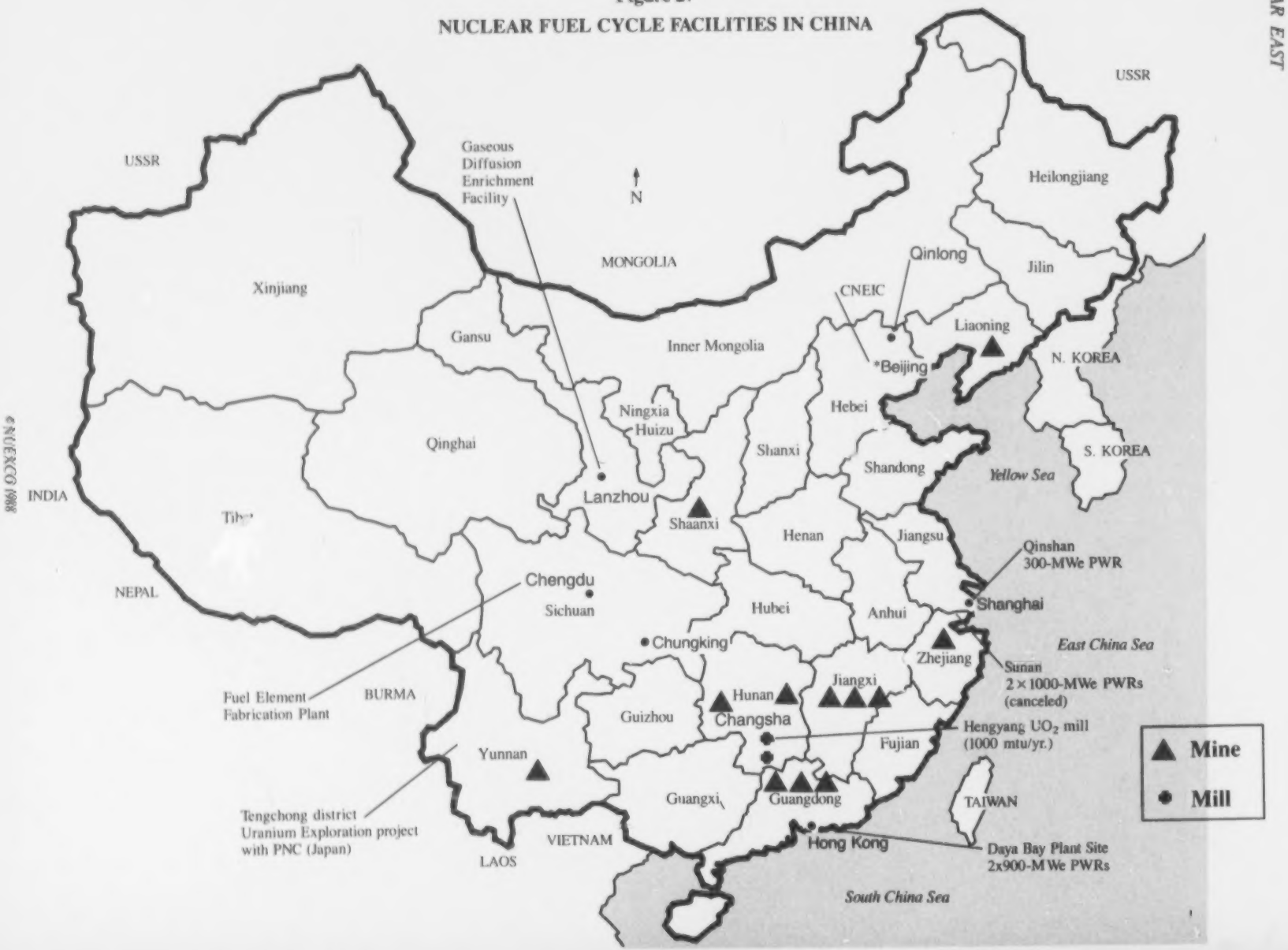
Figure 27

NUCLEAR FUEL CYCLE FACILITIES IN CHINA



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INDIA

Introduction

India operates six commercial reactors, having a combined capacity of 1,330 MWe, and is in the process of making sizeable increases in its nuclear industry infrastructure. Total capacity under development is approximately 1,900 MWe; five 235-MWe reactors are under construction, and another three are in the firm planning or initial site development stage (Table 24). In addition, India also is proceeding on fast breeder development, and in 1985 inaugurated a 40-MW(thermal) test breeder reactor.

India's desire for independence in the fuel cycle, and the associated freedom from international controls and restraints, has led to a reactor program based on Pressurized Heavy Water Reactors (PHWRs), which are closely linked by design to India's two original CANDU reactors, still operating at the Rajasthan complex. The Nuclear Fuel Complex (NFC) at Hyderabad has complete fuel fabrication capability, and domestic reprocessing of spent fuel takes place at several locations.

In August 1987, the Indian Parliament approved the conversion of the Nuclear Power Board into an autonomous, state-owned corporation. The reorganization, although much criticized by several leading figures in India's nuclear industry, is meant to overcome financing problems by raising money through public offering of tradeable securities.

India's Reactor Construction Program

The cracked end-shield of the RAPS unit 1, which caused that reactor's intermittent shutdown since 1981, was again repaired and the unit taken to near half-power (100 MWe) in mid-1987. There has been an ongoing controversy in Indian nuclear circles over whether the plant should be permanently closed because of the end-shield failure.

Throughout 1987, the Indian government conducted nuclear-related talks with the USSR, among other things discussing the possible sale of Soviet VVER-440 reactors to India. One of the problems raised during the negotiations was India's staunch refusal to sign the Non-proliferation Treaty, or to accept comprehensive safeguards over fuel supplied to the units. If India's objections can be tempered or the safeguards issue sidestepped, it is possible that India could buy Soviet nuclear plants in the future.

The Fast Breeder Reactor Program — At Kalpakkam, near Madras in the southern state of Tamil Nadu, the Indira Ghandi Centre for Atomic Research (formerly the Reactor Research Centre) has under development a 40-MWt liquid-metal fast breeder test reactor, the FBTR, which achieved criticality in December 1985. Based on France's Rapsodie breeder, the unit is scheduled to reach rated power by 1988, at a reported cost of about $54 million.

Fuel Fabrication, Reprocessing and Heavy Water

The Nuclear Fuel Complex (NFC) at Hyderabad is the main fuel fabrication unit in India, although some nuclear fuel also is produced at the Bhabha Atomic Research Centre (BARC). The complex produces natural UO_2 fuel bundles for the RAPS and MAPS reactors, as well as enriched uranium fuel assemblies for the Tarapur BWRs. The NFC also contains a plant to manufacture zircaloy and zirconium-niobium alloys for fuel element cladding.

Reprocessing — Reprocessing of spent fuel takes place at several DAE facilities. India's first reprocessing plant was built at the BARC complex in Trombay, and was commissioned in 1964 with a capacity of about 30 tonnes per year. The Indian-designed and built plant uses the Purex process with solvent extraction columns.

The primary reprocessing plant at present is located at the Tarapur reactor site, where since 1982, spent fuel from the Tarapur reactor has been reprocessed. This facility has a rated capacity of 100 tonnes per year. In 1986, the Tarapur plant also reprocessed spent fuel from the MAPS Unit 1 reactor, recovering plutonium to be used in the FBTR. This plant operates under international safeguards only when reprocessing safeguarded material, such as imported enriched UF_6 from the Tarapur BWRs. When reprocessing domestic fuel material, no safeguards apply to its operation.

India's PHWR reactor program depends to a great extent on an adequate supply of heavy water — deuterium (D_2O) — and is committed to domestic supply. The five currently operating heavy water plants have a total capacity of between 250 and 325 tonnes D_2O per year. At present, while India's production of heavy water is close to meeting its requirements, some is regularly imported from the Soviet Union.

Nuclear Fuel Resources

Exploration, mining, and milling of uranium and thorium takes place under the auspices of the DAE. The state-owned Uranium Corporation of India Limited (UCIL) and India Rare Earths Limited (IREL) conduct production

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operations.

India's known reserves of uranium are not particularly large, estimated by OECD/IAEA as of mid-1985 to total 62,700 tonnes U. Of these, about 35,100 tonnes are in the under $80/kg. category, and about 11,000 tonnes are in the $80-130/kg category. 17,000 tonnes are classified as Estimated Additional Resources (EAR). Within the Singhbhum district, west of Calcutta in the state of Bihar, UCIL operates India's only commercial uranium mining facility, an underground mine and mill at Juduguda, in production since the 1960s. Output from this mine and mill is estimated to be approximately 200,000 pounds U_3O_8 per year. Mill capacity is 1,000 tonnes/day of ore, although recently a major expansion of the Juduguda mine and mill has been underway, and a new 3,000 tonne capacity ore-processing plant has been added to the existing facilities.

UCIL is also working to expand production in the Singbhum area by opening new mines at Bhatin and Turamidih. Currently, small plants at Rakha and Mosaboni also contribute to UCIL's uranium operations, operating in conjunction with the concentrators at copper mines.

Although India's present uranium production capability appears adequate to provide fuel supplies for the four operating PHWRs, there is little surplus production available for many new reactors. It is possible that in the future, if the nuclear expansion program is continued, India could become a buyer on the world uranium market.

Table 24

NUCLEAR POWER UNITS IN INDIA

Unit	Capacity (MWe Net)	Type	COD[1]	Percent Complete	1987 Capacity Factor[2] (percent)	Total Electricity Generation in 1987[2] (GWh)
In Commercial Operation						
Tarapur (TAPS) 1	160	BWR	1969	100	11	210
Tarapur (TAPS) 2	160	BWR	1969	100	67	1,224
Rajasthan (RAPS) 1	204	PHWR	1973	100	15	282
Rajasthan (RAPS) 2	184	PHWR	1981	100	67	1,289
Madras (MAPS) 1	215	PHWR	1984	100	58	1,200
Madras (MAPS) 2	215	PHWR	1985	100	62	1,277
Total MWe in Operation	1,138			*(1987 Average)*	47	5,482
Under Construction						
Narora (NAPP)1	220	PHWR	1988	85		
Narora (NAPP)2	220	PHWR	1989	80		
Kakrapar (KAPP) 1	220	PHWR	1991	22		
Kakrapar (KAPP) 2	220	PHWR	1992	17		
Kaiga 1	220	PHWR	1994	—		
Planned						
Kaiga 2	220	PHWR	1995	—		
Rajasthan 3 and 4	220 (ea.)	PHWR	late 1990s	—		
Total	2,898					

[1]Actual or expected Commercial Operation Date.
[2]Source: *Nucleonics Week*.

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SOUTH KOREA

In June 1987, Korea Nuclear Unit 8 (KNU-8, 900-MWe PWR) entered commercial operation. Korea has changed its plant designations, effective January 1988, to correspond to the plant locations, thus KNU-8 is now called Yongkwang Unit 2. (Figure 28 shows locations of South Korea's nuclear facilities.) With the commissioning of the new unit, Korea's nuclear plants contributed 53 percent of the country's electricity in 1987, up from 44 percent in 1986. Total installed nuclear generating capacity is now 5,380 MWe (Table 25). Two 940-MWe PWRs currently are in an advanced stage of construction, and are expected to begin operating in 1988 and 1989, respectively.

In April 1987, the state utility, Korea Electric Power Corporation (Kepco), signed contracts with Combustion Engineering (C-E) of the USA for units 3 and 4 at the Yongkwang site (formerly designated KNU 11 and 12). Construction of these units is expected to begin in 1989, and their eventual completion should increase South Korea's share of nuclear power generation to over 43 percent of the total when they begin producing power around 1996. The units are expected to cost about $3.5 billion.

A number of companies, both South Korean and foreign, will supply equipment to the project, and the contract is based on a high degree of technology transfer to the Korean nuclear industry. In addition to the nuclear steam supply system provided by C-E, the turbine generators will be supplied by General Electric Company of the USA, and some architect-engineering services will be provided by Sargent & Lundy. KEPCO will act as project manager. Earlier nuclear plants in South Korea were largely built as turnkey projects, involving Westinghouse, Atomic Energy of Canada Ltd., and Framatome. The percentage of local manufacture in South Korea's nuclear plants has steadily increased, from under 10 percent for the first plant (KNU 1) to over 40 percent for units 8 and 9. For the new plants

Table 25

NUCLEAR POWER UNITS IN SOUTH KOREA

Unit[1]	MWe	Type	COD[2]	Percent Complete	1987 Capacity Factor[3] (percent)	Total Electricity Generation in 1987[3] (GWh)
Kori 1 (KNU 1)	556	PWR	1978	100	94	4,834
Kori 2 (KNU 2)	605	PWR	1983	100	80	4,543
Kori 3 (KNU 5)	895	PWR	1985	100	73	6,077
Kori 4 (KNU 6)	895	PWR	1986	100	74	6,131
Uljin 1 (KNU 9)	943	PWR	1988	100*	4	—
Uljin 2 (KNU 10)	943	PWR	1989	71	—	—
Wolsung 1 (KNU 3)	629	CANDU	1983	100	93	5,521
Yongkwang 1 (KNU 7)	900	PWR	1986	100	72	6,260
Yongkwang 2 (KNU 8)	900	PWR	1987	100	91	4,481
Yongkwang 3 (KNU 11)	943	PWR	1995	planned	—	—
Yongkwang 4 (KNU 12)	943	PWR	1996	planned	—	—
Total	9,152			(1987 average)	82	37,848

[1]Name designations have been changed, effective January 1, 1988. The former designations are given in parens.
[2]Actual or expected Commercial Operation Date.
[3]Source: Nucleonics Week.
[4]Uljin Unit 1 achieved criticality February 25, 1988.

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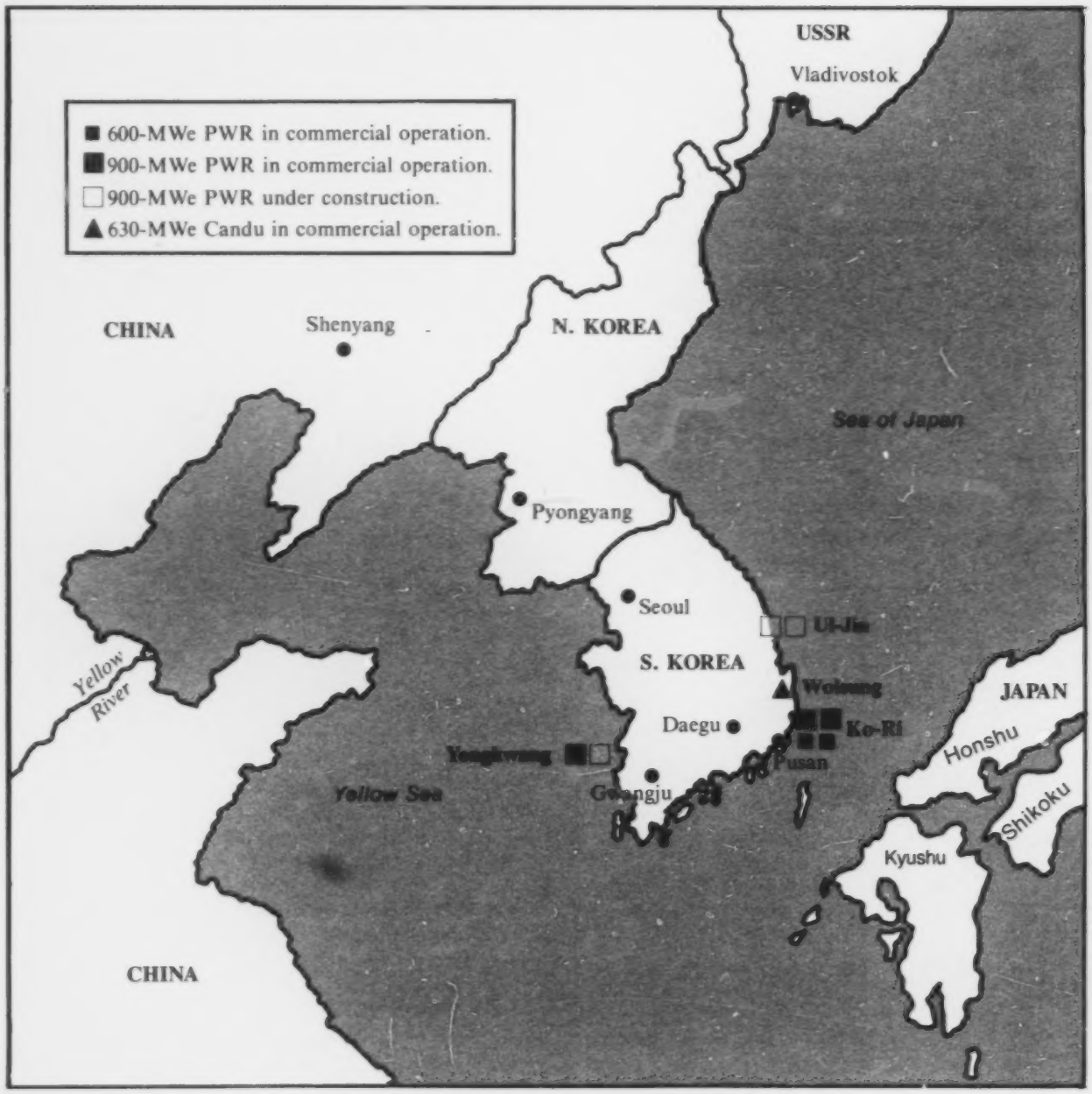
NUEXCO

FAR EAST

Figure 28

NUCLEAR POWER UNITS IN SOUTH KOREA



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(Yongkwang 3 and 4), South Korean companies are expected to supply about 70 percent of the equipment, in terms of cost.

Nuclear power development in South Korea is largely controlled by KEPCO, which owns or has controlling interest in a number of smaller companies that will provide equipment and services. KEPCO's engineering subsidiary, the Korea Power Engineering Company (KOPEC) is responsible for architect-engineering and conducts joint ventures and other cooperative arrangements with overseas companies. KOPEC will manage balance-of-plant engineering for the new nuclear plants. KEPCO also manages the Korea Heavy Industries and Construction Company (KHIC), which is the designated manufacturer and umbrella licensee to the main foreign nuclear industry suppliers. KHIC will be the prime contractor for the new plant, and as such, can award subcontracts to smaller Korean companies. Manufacturing of the main components will be divided between KHIC, General Electric and C-E.

Work continued on construction of a fuel fabrication facility at Taejon, part of South Korea's overall plan to become as self-sufficient as possible in nuclear technology. The plant will have a production capacity of about 200 tonnes per year, and will cost an estimated $65 million. Kraftwerk Union is providing the basic design in collaboration with Reaktor-Brennelement Union. Korea Nuclear Fuels Company, a subsidiary of KEPCO, will operate the plant. The plant is scheduled to begin operation in 1989, and will have sufficient capacity to supply fabricated fuel for all of South Korea's nuclear reactors through at least the mid-1990s.

Korea's annual uranium consumption currently is about 1,100 MTU, increasing to about 1,200 MTU when the two newly-ordered units come into operation in about 1997. Nearly all of Korea's requirements are met through long-term contracts, primarily with Canadian and Australian suppliers. In October 1987, KEPCO signed a contract with the Olympic Dam partners for deliveries of over 500,000 pounds U_3O_8 per year between 1988 and 1998.

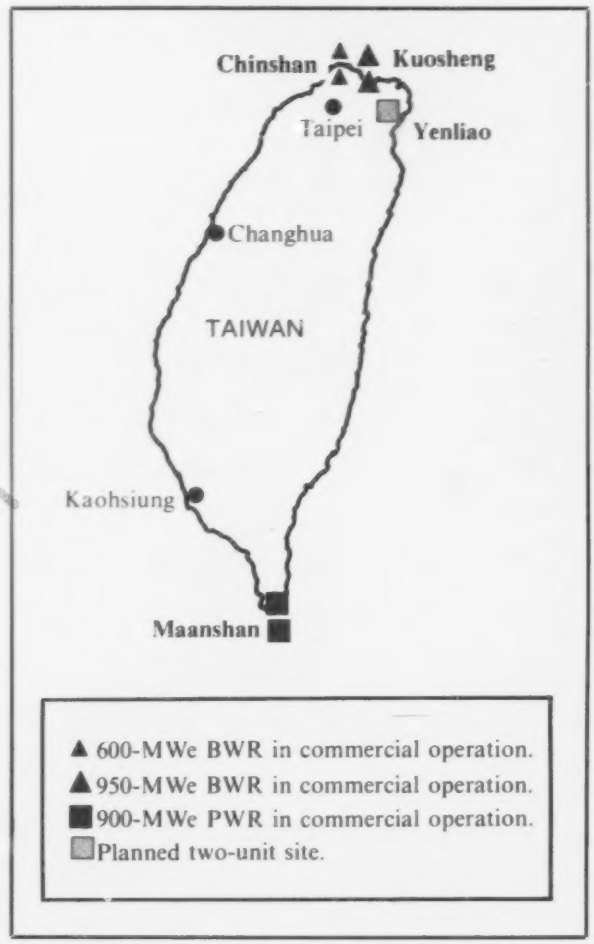
KEPCO also is involved in other countries as an investor in several uranium projects under development, and in uranium exploration. In August 1987, KEPCO bought a 2 percent (non-voting) share in the Cigar Lake Project from the Saskatchewan Mining Development Corp.; the Korean company will take delivery of over 600,000 pounds U_3O_8 per year from the project from 1994 to 2003. KEPCO also owns a 20 percent share of the Crow Butte solution mining project in the USA, expected to begin operation in 1988. KEPCO also has invested in the Norde Leyou project in Gabon, and another Korean company, Daewoo, has a small financial interest in the Canadian Kiggavik project.

South Korea is also planning a waste repository to be ready for operations in the mid-1990s. Spent fuel from South Korean nuclear units will be held in interim storage until the $1.6 billion repository is opened by KEPCO.

TAIWAN

Taiwan's six nuclear reactors (Table 26) continued to operate well in 1987, but the future direction of its nuclear program remained uncertain. The 1985 decision by the Ministry of Economic Affairs to suspend planning and site preparation work for the country's next two nuclear units continued in force, pending completion of a new feasibility study. The two units originally had been expected to begin operation in the early 1990s, at Yenliao, on the coast east of Taipei (Figure 29). Even if the two proposed units were

Figure 29
NUCLEAR POWER UNITS IN TAIWAN



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approved in early 1988, they would not be commissioned before about 1996 and 1997.

The delay in starting the nuclear units has resulted in the government planning to add as many as four additional 550-MWe coal-fired generating plants to the existing plans for non-nuclear power facilities. Electricity growth rates have averaged about 10 percent per year since the early 1970s, but in the past couple of years have slowed markedly. Taipower now projects a future electricity growth rate of about 6 percent per year.

Maanshan Unit one operated throughout the year, after being shut down between July 1985 and October 1986, when parts of the General Electric (GE) turbine fragmented. Taipower, the state utility, has settled its claim against GE regarding the turbine problem, with GE agreeing to meet the cost of repairs (completed in 1986, and paid for by GE in the interim) but not the cost of lost power generation, for which Taipower wanted compensation.

Much of the uranium for Taiwan's reactors has been supplied by South Africa, and Taiwan's position with regard to the Nuclear Non-Proliferation Treaty has limited its procurement options. Although Taiwan ratified the treaty in 1970, its subsequent expulsion from the United Nations group of organizations (including the IAEA), when the UN accredited the People's Republic of China, has made Taiwan's diplomatic situation even more complicated. Of the uranium supplying countries, only the Republic of South Africa has formal diplomatic relations with Taiwan. Under a bilateral agreement, however, Taiwan also imports uranium from the USA.

Unlike Japan and South Korea, Taiwan has not tried to develop a self-sufficient program in nuclear technology. The country has not announced any plans to begin developing domestic fuel cycle facilities, nor has it tried to develop fast breeder or other reactor designs.

Table 26

NUCLEAR POWER UNITS IN TAIWAN

Unit	MWe	Type	COD[1]	Percent Complete	1987 Capacity Factor[2] (percent)	Total Electricity Generation in 1987[2] (GWh)
Chinshan 1	604	BWR	1978	100	75	4,195
Chinshan 2	604	BWR	1979	100	70	3,925
Kuosheng 1	948	BWR	1981	100	76	6,597
Kuosheng 2	948	BWR	1983	100	78	6,727
Maanshan 1	890	PWR	1984	100	59	4,956
Maanshan 2	890	PWR	1985	100	81	6,727
Total	4,884				(1987 avg.) 73	33,108

[1]Actual or expected Commercial Operation Date.
[2]Source: *Nucleonics Week*.

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ARGENTINA

Uranium Production

Between 1978 and 1987, uranium production in Argentina ranged between 253,000 and 486,000 pounds U_3O_8 per year (Figure 30). Production has dropped each year since 1983, when it was 448,000 pounds U_3O_8, to an estimated 253,000 pounds in 1987. Thus, recent output has been somewhat below that needed to provide fuel for the two operating reactors, although it is estimated that Argentina has about a two-year forward supply of uranium in inventory. To date, Argentina's uranium production efforts have primarily been aimed at achieving self-sufficiency.

Total uranium reserves are thought to be about 520 million pounds U_3O_8, of which only about 50 million pounds are considered Reasonably Assured Resources (RAR) and about 39 million pounds are accessible at under $36 per pound ($80/kg)*. The main deposits are at Los Gigantes (Cordoba Province), Sierra Picinan (Chubut Province), Sierra Pintada (Mendoza Province) and Tonco-Amblayo (Salta Province). Argentine official sources say that most uranium is recovered for about $20 per pound, with costs higher than that at Los Gigantes, where CNEA has said it is losing money.

At present, there are three operating uranium mines in Argentina.

1. *San Rafael* — Located near the Sierra Pintada orebody in Medoza Province, about 150 miles (250 km) south of the provincial capital of Mendoza, this mine produces uranium from heap leaching, with a current capacity of about 300,000 pounds U_3O_8 per year. 1987 production was approximately 140,000 pounds U_3O_8. This orebody contains Argentina's largest uranium reserves — some 42 million pounds U_3O_8.

2. *Los Gigantes* — Los Gigantes is located in Cordoba Province, about 300 miles (500 km) northwest of Buenos Aires. Target 1987 production was 150,000 pounds, but it is estimated that about 90,000 pounds actually was produced. Since opening in December 1982, the mine's output has averaged about 115,000 pounds U_3O_8 per year, even though milling capacity is over 250,000 pounds per year. In late 1986 through early 1987, the operation was closed for several months due to charges by the Cordoba Provincial government that it was ignoring environmental regulations.

3. *La Estela* — This mine is in San Luis Province, about 400 miles (650 km) west of Buenos Aires. 1987 production from the La Estela mine and mill was about 26,000 pounds U_3O_8.

Argentina's Reactor Program

Nuclear-generated electricity accounted for about 11 percent of the total in 1985 and 1986. Argentina has two operating commercial units (and one under construction), and four research reactors. Argentina's first reactor was Atucha Unit 1, a KWU-designed 335-MWe (Net) PHWR that entered service in 1974. The Atucha complex is located at Zarate, about 45 miles (70 km) northwest of Buenos Aires. The reactor is used for daily load cycling, and through the end of 1986, its cumulative lifetime load factor was 71.5 percent. In 1983, a second PHWR, a 600-MWe CANDU designed by AECL, went into operation at Embalse, near Cordoba. Lifetime cumulative load factor at the end of 1986 was 53.5 percent.

The second unit at the Atucha site (698-MWe net PHWR) currently is about half completed and is now tentatively scheduled to go into operation in 1993. The plant's architect/engineer is ENACE (Empresa Nuclear Argentina de Centrales Electricas) which is 25-percent owned by KWU and the remainder by the CNEA. The design was supplied by KWU. The reactor's pressure vessel arrived on-site in March 1987. The main part of the vessel was forged in Japan by Mitsubishi Heavy Industries, and was then shipped to Rotterdam, Holland, where the 320-tonne cover dome from Spain was installed and final assembly completed. A recent ENACE estimate put the final cost of the reactor at a minimum of $2.6 billion, excluding interest on the project-related loans, which could run as high as 30 percent of capital costs. The plant will import at least $900 million in equipment and services from abroad, primarily from the FRG.

Fuel Cycle Facilities

Enrichment — Construction continued in 1987 on Argentina's pilot enrichment plant at Pilcaniyeu, 700 miles (1,150 km) southwest of Buenos Aires near the resort area of San Carlos de Bariloche. The plant is scheduled to begin operation at a rate of 10,000 SWU per year in mid-1988, with an expansion to 20,000 SWU per year planned to begin in 1989. The plant's cost is estimated to be approximately $200 million thus far. The plant's target enrichment level is 20-percent U^{235}; at that enrichment level, 20,000 SWU could provide over 500 kilograms of enriched UF_6. This capacity also could provide nearly 40 tonnes of enriched UF_6 at the 1.2 percent sometimes quoted as a

* *Uranium Resources, Production and Demand*, prepared by the OECD Nuclear Energy Agency and the International Atomic Energy Agency, 1986.

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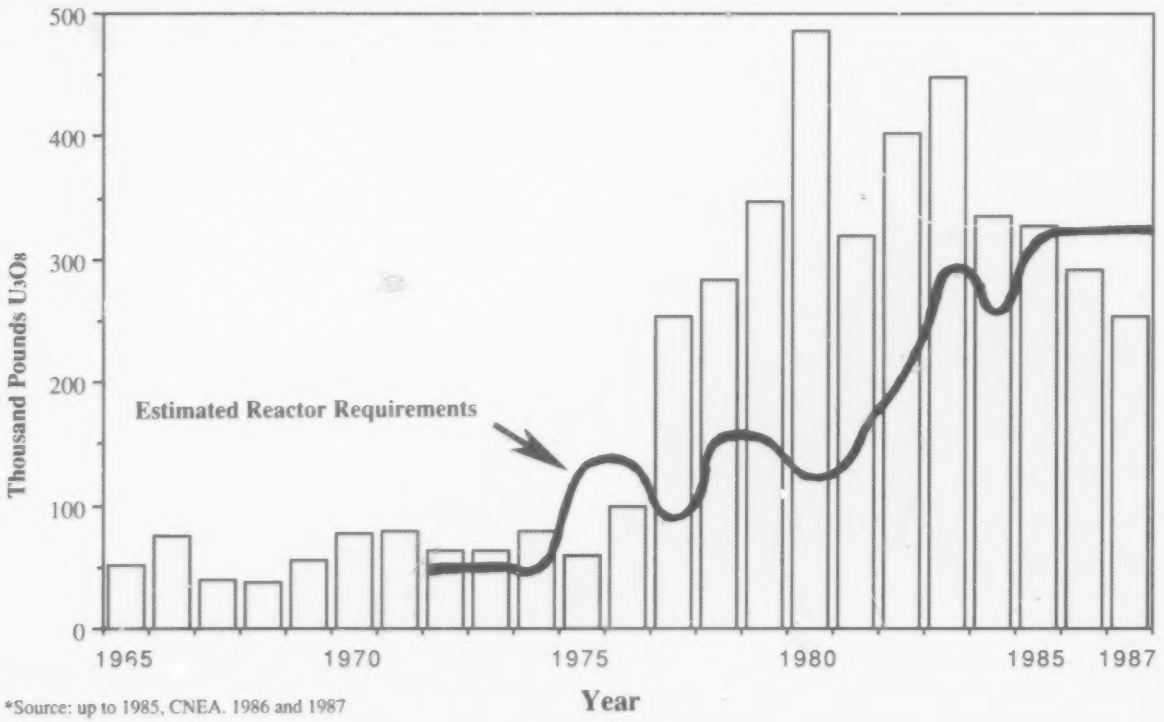
possible enrichment level for Argentina's PHWRs. The Pilcaniyeu project is under extremely tight security, and is accorded a high degree of priority at the central government level. The project also is important as an example of Argentine technical expertise and independence from larger countries. Argentina reportedly has purchased enrichment services abroad, including a purchase in 1982 of 100 kg of uranium enriched to 20-percent U_{235} in the USSR.

Reprocessing — CNEA is constructing a pilot reprocessing plant at Ezeiza, near Buenos Aires, which is over 80-percent complete. It uses technology acquired from Italy's Technint SpA. for basic engineering. The plant is scheduled for cold testing during the second half of 1988 and for hot-testing and initial use on spent fuel from Atucha-1 in 1989. Initially, the pilot plant's capacity will be 5 tonnes of spent fuel per year, recovering up to 15 kg of plutonium.

Fuel Fabrication — A fuel fabrication unit also is being built at the Ezeiza facility, with zircaloy production scheduled for 1990. CNEA closed its pilot zirconium sponge plant in 1982 to concentrate on building a larger-scale unit. A UO_2 plant is in operation in Cordoba Province, apparently processing all domestic U_3O_8 for fabrication.

Heavy Water — Argentina currently has a pilot heavy water (D_2O) production plant under construction at Zarate, site of the Atucha reactors, and a full-scale plant at Arroyito, in Neuquen Province. The Zarate plant, with a capacity of 2 to 8 tonnes per year, has been under construction since the mid-1970s, and it is scheduled to begin operation in mid-1988, using the water-hydrogen sulfide ion exchange process, at an estimated cost of $100 million. Sulzer Bros. of Switzerland hopes to finish the twin 125 tonnes-per-year production lines at the Arroyito facility in 1988, with production beginning in mid-1989. Capacity will be about 100 tonnes for the first year, rising to about 150 tonnes the second year, and averaging about 200 tonnes thereafter.



*Source: up to 1985, CNEA. 1986 and 1987 figures are Nuexco estimates.

Figure 30
URANIUM PRODUCTION IN ARGENTINA

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BRAZIL

Brazil has one nuclear unit currently in commercial operation, a 626-MWe PWR at the Angra station, built by Westinghouse and in intermittent operation since 1984. A second unit is under construction at the Angra site, a 1,245-MWe PWR designed by Kraftwerk Union and being built in cooperation with Brazilian companies, and a third similar unit also is in the preliminary stages of construction. Angra Unit 2 is about 30-percent complete and is scheduled for commercial operation in about 1992. Unit 3, whose eventual completion is in doubt due to lack of funds, is tentatively scheduled to begin operation in 1995.

Fuel Cycle Facilities — Brazil has devoted a considerable amount of effort to developing domestic enrichment capability. In October 1987, President Jose Sarney announced that Brazilian scientists had enriched a small quantity of uranium using an indigenous "ultracentrifuge" process. Based on this research effort, Brazil reportedly plans to complete a pilot plant at Ipero, about 125 km west of Sao Paulo, followed by an industrial-scale unit that will aim for enrichment at levels up to 20-percent U_{235}. A 1975 nuclear technology agreement between Brazil and the FRG had resulted in a demonstration enrichment plant being built at Rezende, using the "Becker jet-nozzle" process, but that plant has not resulted in Brazil producing commercial quantities of enriched uranium. It is not clear whether Brazil will continue with development work at Rezende or shift all its effort toward the newer domestic process.

Uranium Resources — Brazil's uranium reserves are substantial; Reasonably Assured Resources (RAR) are estimated at about 163,000 tonnes U in the under $80 per kg category. Production of uranium concentrates at the Pocos de Caldas mine and mill peaked in 1982 at about 600,000 pounds (285 tonnes) U_3O_8 (Figure 31), but has declined since that time, largely due to the decrease in anticipated demand caused by the slow progress of the domestic nuclear power program. Cost of production at the Pocas de Caldas facility is thought to be relatively high. Should Brazil's nuclear power program proceed on schedule, production in the 1990s from the Pocos de Caldas facility could reach as high as 550,000 pounds U_3O_8 per year.

Another site is under development at Itataia in Ceara state, in which uranium is expected to be extracted as a by-product of phosphoric acid production. This facility could begin supplying uranium by about 1993 at an annual rate of about 250,000 pounds U_3O_8, increasing to as much as 1.5 million pounds per year (about 700 tonnes) by the end of the century. A pre-feasibility study also was started in 1987 to evaluate possible future production at the Lagoa Real mine in Bahia state. This mine could produce up to 1.5 million pounds U_3O_8 annually.

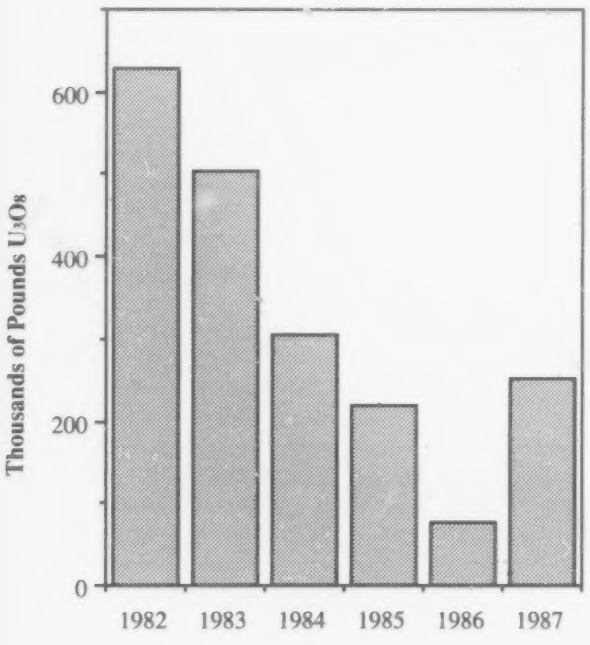

Figure 31

URANIUM PRODUCTION IN BRAZIL, 1982 to 1987

MEXICO

Mexico's Laguna Verde Unit 1 (654-MWe BWR) was essentially completed in 1987, and the plant began loading fuel in early 1988. Commercial operation is expected in late 1988. The reactor is located near the city of Vera Cruz on the Gulf of Mexico. A second twin unit at the Laguna Verde site is about 50-percent complete, but its construction currently is suspended.

Mexico has several uranium deposits, and reserves are sufficient to fuel the Laguna Verde reactor for at least 30 years. Commercial development, however, has not progressed since it was halted in 1984 due to Mexico's economic difficulties and the dissolution of URAMEX in that year. Even though long-range government plans call for self-sufficiency in uranium production to meet the needs of the nuclear power program, there is currently little capital available for development of uranium mining.

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SOUTHERN AFRICA

NAMIBIA

Nuexco estimates that Namibian uranium production in 1987 totaled approximately 9.2 million pounds U_3O_8, nearly the same as the 1986 level. The sole source of uranium production in Namibia is Rossing Uranium Ltd.'s Rossing project, the world's largest open-pit uranium mine. Nuexco forecasts indicate that output from this mine will continue to be near the 8 million pound U_3O_8 level for the foreseeable future.

SOUTH AFRICA

Uranium production in the Republic of South Africa continued to decline in 1987, to approximately 10,300,000 pounds U_3O_8, a drop of 14.2 percent from the previous year's total of almost 12 million pounds (Table 27). These figures include production from both Chamber of Mines producers and the Palabora Mining Company. Part of the decline resulted from labor disruptions caused by the lengthy strike called by the Mineworkers Union, which caused third-quarter output to drop substantially at several mines, including **Freegold** (down 6 percent since 1986), **Randfontein** (down 23 percent), **Vaal Reefs** (down 13 percent) and **Western Areas** (down 23 percent). In addition, **Buffelsfontein** experienced a 25 percent drop in annual production due to lower ore production and insufficient ore reserves in its Strathmore Shaft Area. Output from **Harmony** declined 46 percent from 1986, primarily due to the closure of its Virginia plant in mid-1986. The only significant increase came from **Stilfontein's** Chemwes facility, up 48 percent from the

Table 27

REPUBLIC OF SOUTH AFRICA
RECENT URANIUM PRODUCTION[1]
(Thousands of Pounds U_3O_8)

Operation	Total 1986	First Quarter 1987	Second Quarter 1987	Third Quarter 1987	Fourth Quarter 1987	Total 1987	Percent Change[2]
Buffelsfontein	1,316	271	245	240	229	985	- 25.2
Driefontein Consolidated	180	41	41	42	36	161	- 10.6
ERGO[3]	343	88	79	85	93	345	- 0.6
Freegold[4]	1,168	275	245	223	277	1,020	- 12.7
Harmony	728	102	103	97	90	393	- 46.0
Hartebeestfontein	1,025	242	231	223	219	916	- 10.6
Randfontein	1,324	314	297	148	259	1,019	- 23.0
Stilfontein (Chemwes)	638	228	234	232	239	933	+ 46.2
Vaal Reefs	4,255	1,025	977	768	927	3,697	- 13.1
Western Areas	585	127	104	124	98	452	- 22.7
Palabora Mining Co.	408	87	87	87	87	346	- 15.2
TOTAL[5]	11,970	2,801	2,642	2,270	2,553	10,266	- 14.2

[1]Includes both Chamber of Mines producers and the Palabora Mining Co., which does not belong to the Chamber of Mines.
[2]Change in percent from 1986 total.
[3]ERGO = East Rand Gold and Uranium Company Ltd.
[4]Formerly Free State Joint Metallurgical Scheme.
[5]Columns may not add due to rounding.

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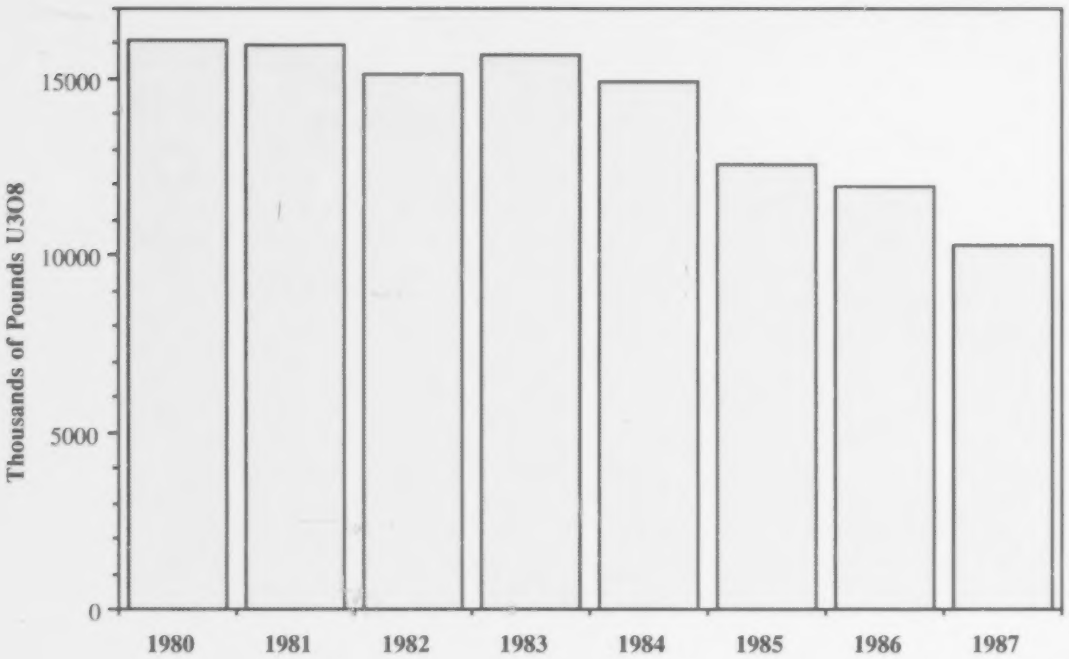

Figure 32

SOUTH AFRICAN URANIUM PRODUCTION, 1980 TO 1987

1986 level. The increase came from additional sales and bringing forward deliveries that were due in 1990 and 1991; this enabled an increase in plant capacity utilization from 80 percent in 1986 to 100 percent in 1987. Production at **Palabora** was 346,000 pounds U_3O_8, a drop of 15 percent from the 1986 total of 408,000 pounds.

In August 1987, despite the opposition of the Conservative Party, the South African Parliament formally repealed the definition of "scheduled person," which reserved a number of key jobs in the mining industry for whites and certain categories of "colored" persons. Other coloreds, Indians and blacks were excluded from the definition. This distinction has been an integral part of the Mines and Works Act since 1911, when the Act was first promulgated. Thus, the last legal barrier to employment based on merit rather than race has been removed.

Under the Mines and Works Act, only "scheduled persons" were allowed to obtain qualifications for the 13 "certificates of competency" that were required to perform certain tasks, and hence, to hold certain jobs. About three-percent of the total South African mining workforce, or about 15,000 employees, hold jobs requiring the certificate of competency, including mine managers, overseers, surveyors, mechanical and electrical engineers, various machinery operators, and others. In particular, only scheduled persons could hold the blasting certificate, required for all jobs above that of team leader in the production (as opposed to engineering) side of mining operations. With the abolition of the scheduled person definition, blacks and others meeting the necessary requirements will be able to obtain the blasting certificate and other certificates of competency, and therefore advance up the hierarchy.

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UNITED STATES

Nuclear Power Developments

Seven reactors entered commercial service in the USA in 1987, adding over 7,000 MWe of installed capacity to the US nuclear generating base (Table 28). By the end of the year, four other reactors had received full-power licenses, and one had received a low-power license, but those units have yet to enter commercial operation. This compares favorably to the progress made in 1985 and 1986, in which eight new units entered service in each year.

Commonwealth Edison Company's **Byron Unit 2** (1,120-MWe PWR) formally entered service in April 1987, almost two months ahead of schedule. The company's **Braidwood Unit 1** (1,120-MWe PWR) also began operating in April 1987, although it has not been formally declared to be in "commercial operation" under the Illinois Commerce Commission's (ICC) definition of the term. The ICC had earlier approved the plant's operation.

Also in April, Illinois Power Company's **Clinton Unit 1** (933-MWe BWR) was connected to the power grid, beginning power ascension and testing. The unit was actually placed in service in November, although, as in the case of Braidwood Unit 1, the ICC had not formally granted it commercial status.

Carolina Power & Light Company's **Shearon Harris Unit 1** (900-MWe PWR) was declared to be in commercial operation at the beginning of May 1987. The plant's construction cost reached $3.8 billion, and it is the only unit to be constructed at that site, after three other units initially planned for the site were canceled several years earlier.

Duquesne Light Company's **Beaver Valley Unit 2** (833-MWe PWR) entered service in November 1987, having the distinction of being the first US reactor to be granted a full power license without a direct public vote by the NRC commissioners, since the accident at Three Mile Island in 1978.

Cleveland Electric Illuminating Company's **Perry Unit 1** (1,205-MWe BWR) also entered service in November. The unit had been completed since January 1987, but the occurrence of an earthquake near the plant site caused an intervention in the NRC proceedings, delaying licensing until November.

Georgia Power Company's **Vogtle Unit 1** (1,100-MWe PWR) entered commercial operation at the end of May 1987. Construction of the unit began in 1974, and the total cost of the two-unit plant (Unit 2 is scheduled to begin operation in 1989) is nearly $9 billion.

The US nuclear backlog continues to shrink, and, excluding units that are either held up by regulatory or legal problems (such as Seabrook and Shoreham), or are considered indefinitely deferred, there are only nine reactors left under active construction that have not yet received at least fuel-loading licenses (Table 29). Eight reactors remain either deferred or officially still on order.

Figure 33. Arizona Public Service Company's Palo Verde Nuclear Station.

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Table 28

US NUCLEAR UNITS' LICENSING PROGRESS DURING 1987[1]

Unit	Utility	MWe Net	Type	COD[2]
Entered Commercial Operation				
Braidwood 1	Commonwealth Edison	1,120	PWR	Apr 1987
Byron 2	Commonwealth Edison	1,120	PWR	Apr 1987
Clinton 1	Illinois Power	933	BWR	Apr 1987
Shearon Harris	Carolina Power and Light	900	PWR	May 1987
Vogtle 1	Georgia Power	1,100	PWR	May 1987
Beaver Valley 2	Duquesne Light Company	833	PWR	Nov 1987
Perry 1	Cleveland Electric	1,205	BWR	Nov 1987
Total		7,211		
Received Full-Power License				
Fermi 2	Detroit Edison	1,093	BWR	Jan 1988
Nine Mile Point 2	Niagara Mohawk	1,080	BWR	Mar 1988
Palo Verde 3	Arizona Public Service	1,221	PWR	Jun 1988
Received Low-Power or Fuel-Loading Licenses				
Braidwood 2	Commonwealth Edison	1,120	PWR	4th Q/ 1988
South Texas 1	Houston Lighting and Power	1,250	PWR	Sep 1988
Total		5,764		

[1]Indicates licensing status as of the end of 1987.
[2]COD = Commercial Operation Date.

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UNITED STATES

Table 29

US NUCLEAR UNITS UNDER CONSTRUCTION AND ON ORDER

Unit	Utility	MWe (net)	Type	Percent Complete	COD[1]
Comanche Peak 1	Texas Utilities	1,150	PWR	99	mid-1989
Comanche Peak 2	Texas Utilities	1,150	PWR	87	mid-1989
South Texas 2	Houston Lighting and Power	1,250	PWR	70	June 1989
Vogtle 2	Georgia Power	1,100	PWR	75	June 1989
Limerick 2	Philadelphia Electric	1,055	BWR	78	Oct 1990
Watts Bar 1	Tennessee Valley Authority	1,177	PWR	99	1990
Watts Bar 2	Tennessee Valley Authority	1,177	PWR	85	1992
Bellefonte 1	Tennessee Valley Authority	1,213	PWR	85	1994
Bellefonte 2	Tennessee Valley Authority	1,213	PWR	55	1996
Total		10,485			
Shoreham	Long Island Lighting	809	BWR	100	indefinite
Seabrook	Public Service New Hampshire	1,150	PWR	100	indefinite
WNP 3	Washington PPSS	1,240	PWR	75	indefinite
WNP 1	Washington PPSS	1,250	PWR	63	indefinite
Perry 2	Cleveland Electric	1,205	BWR	57	indefinite
Grand Gulf 2	Mississippi Power & Light	1,250	BWR	33	indefinite
Carroll County 1*	Commonwealth Edison	1,120	PWR	0	2001
Carroll County 2*	Commonwealth Edison	1,120	PWR	0	2002
Total		9,144			

*Indicates unit is on order.
[1]COD = Commercial Operation Date.

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Table 30

COMMERCIAL NUCLEAR POWER STATIONS IN THE USA

	Fuel Buyer	Station	Units
1.	Yankee Atomic Group (1)	Maine Yankee	■
2.	Yankee Atomic Group (1)	Seabrook	□
3.	Yankee Atomic Group (1)	Vermont Yankee	●
4.	Yankee Atomic Group (1)	Yankee Rowe	■
5.	Yankee Atomic Group (1)	Haddam Neck	■
6.	Boston Edison Co.	Pilgrim	●
7.	Northeast Utilities	Millstone	● ■ ■
8.	Long Island Lighting Co.	Shoreham	○
9.	Consolidated Edison Co. New York	Indian Point 2	■
	New York Power Authority	Indian Point 3	■
10.	New York Power Authority	James A. Fitzpatrick	●
11.	Niagara Mohawk Power Corp.	Nine Mile Point	● ○
12.	Rochester Gas and Electric Corp.	Robert E. Ginna	■
13.	Pennsylvania Power and Light Co.	Susquehanna	● ●
14.	Philadelphia Electric Co.	Limerick	● ○
15.	Philadelphia Electric Co.	Peach Bottom	◕ ●
16.	GPU Nuclear Corp.	Three Mile Island	■ ◧
17.	GPU Nuclear Corp.	Oyster Creek	●
18.	Public Service Electric and Gas	Salem	■ ■
19.	Public Service Electric and Gas	Hope Creek	●
20.	Baltimore Gas and Electric Co.	Calvert Cliffs	■ ■
21.	Virginia Electric Power Co.	North Anna	■ ■
22.	Virginia Electric Power Co.	Surry	■ ■
23.	Carolina Power and Light Co.	Shearon Harris	■
24.	Carolina Power and Light Co.	Brunswick	● ●
25.	Carolina Power and Light Co.	H.B. Robinson	■
26.	Duke Power Co.	William McGuire	■ ■
27.	Duke Power Co.	Catawba	■ ■
28.	Duke Power Co.	Oconee	■ ■ ■
29.	South Carolina Electric and Gas	Summer	■
30.	Tennessee Valley Authority	Sequoyah	◧ ◧
31.	Tennessee Valley Authority	Watts Bar	□ □
32.	Tennessee Valley Authority	Bellefonte	□ □
33.	Tennessee Valley Authority	Browns Ferry	◐ ◐ ◐
34.	Southern Company Services	Alvin W. Vogtle	■ □
35.	Southern Company Services	Edwin I. Hatch	● ●
36.	Southern Company Services	Joseph M. Farley	■ ■
37.	Florida Power Corp.	Crystal River	■
38.	Florida Power and Light Co.	St. Lucie	■ ■
39.	Florida Power and Light Co.	Turkey Point	■ ■
40.	Gulf States Utilities Co.	River Bend	●
41.	Middle South Utilities	Waterford	■
42.	Middle South Utilities	Grand Gulf	● ○
43.	Middle South Utilities	Arkansas Nuclear	■ ■
44.	Union Electric Co.	Callaway	■
45.	Illinois Power Co.	Clinton	●
46.	Commonwealth Edison Co.	Quad Cities	● ●
47.	Commonwealth Edison Co.	Byron	■ ■
48.	Commonwealth Edison Co.	La Salle	● ●
49.	Commonwealth Edison Co.	Dresden	● ●
50.	Commonwealth Edison Co.	Zion	■ ■
51.	Commonwealth Edison Co.	Braidwood	■ □
52.	CAPCO (2)	Davis-Besse	■
53.	CAPCO (2)	Beaver Valley	■ ■
54.	CAPCO (2)	Perry	● ○
55.	Detroit Edison Co.	Fermi	●
56.	American Electric Power Co.	Cook	■ ■
57.	Consumers Power Co.	Palisades	■
58.	Consumers Power Co.	Big Rock Point	●
59.	Wisconsin Public Service Corp.	Kewaunee	■
60.	Wisconsin Electric Power Co.	Point Beach	■ ■
61.	Dairyland Power Cooperative	La Crosse	◕
62.	Northern States Power Co.	Monticello	●
63.	Northern States Power Co.	Prairie Island	■ ■
64.	Iowa Electric Light and Power Co.	Duane Arnold	●
65.	Omaha Public Power District	Fort Calhoun	■
66.	Nebraska Public Power District	Cooper	●
67.	Kansas Gas and Electric Co.	Wolf Creek	■
68.	Texas Utilities Electric Co.	Comanche Peak	□ □
69.	Houston Lighting and Power Co.	South Texas Project	□ □
70.	Public Service Co. of Colorado	Fort St. Vrain	▲
71.	Arizona Public Service Co.	Palo Verde	■ ■ □
72.	Southern California Edison Co.	San Onofre	■ ■ ■
73.	Pacific Gas and Electric Co.	Diablo Canyon	■ ■
74.	Sacramento Municipal Utility District	Rancho Seco	■
75.	Portland General Electric Co.	Trojan	■
76.	U.S. Department of Energy	Hanford	▲
77.	WPPSS	WNP 1 and 2	□ ●
78.	WPPSS	WNP 3	□

[1]Consists of Maine Yankee Atomic Power Company, Vermont Yankee Nuclear Power Corporation, Public Service Company of New Hampshire, Yankee Atomic Electric Company.
[2]CAPCO = Centeral Area Power Coordinating Group

Figure 34

MAP OF US NUCLEAR POWER STATION AND ACTIVE URANIUM PRODUCTION SITF

OPERATING URANIUM PRODUCTION FACILITIES IN THE USA[1]

	Company	Location	Method
A.	Pathfinder Mines	Gas Hills, Wyoming	Conventional
B.	Pathfinder Mines	Shirley Basin, Wyoming	Conventional
C.	Cotter Corp.	Canon City, Colorado	Conventional
D.	Rio Algom Corp.	La Sal, Utah	Conventional
E.	Umetco/Energy Fuels	Blanding, Utah	Conventional
F.	Homestake Mining Co.	Grants, New Mexico	Conventional
G.	Chevron Resources Co	Hobson, texas	Conventional
H.	IEC[2]	Three Rivers, Texas	Solution
I.	Everest Minerals Corp.	Hobson, Texas	Solution
J.	US Steel/Niagara Mohawk Uranium	George West, Texas	Solution
K.	Mobil Inc.	Bruni, Texas	Solution
L.	Malapai Resources	Powder River Basin, Wyo.	Solution
M.	Total Minerals	West Cole, Texas	Solution
N.	Freeport Uranium	Donaldsonville and Uncle Sam, Louisiana	By-Product
O.	IMC[3]	New Wales and Plant City, Florida	By-Product
P.	Energy Fuels	Bingham, Utah	By-Product

[1]Active during 1987.
[2]IEC = Intercontinental Energy Corporation.
[3]IMC = International Minerals and Chemical Corporation.

LEGEND

	In Commercial Operation	Under Licensing or Construction	Shutdown Indefinitely
PWR	■	□	◧
BWR	●	○	◐
Other	▲	△	◭

Active Uranium Production Sites
✚ = Conventional mill
✚ = Solution or by-product operation

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The US Producers vs. DOE Lawsuit

Background

In December 1984, three US producers — Western Nuclear, Inc.; Energy Fuels Nuclear, Inc.; and Uranium Resources, Inc. — filed a five-count lawsuit against DOE in the US Tenth Circuit Court in Denver, Colorado. Judge Jim Carrigan was assigned the case. The lawsuit was the result of efforts, begun in 1980, to protect domestic uranium production from low-cost imports and to maintain the viability of the domestic industry.

Count I requested a reimposition of the US embargo on the enrichment of foreign uranium. It asserted that, under the Atomic Energy Act (161(v), 42 U.S.C. 2201(v), enacted in 1964), DOE is obligated to limit the enrichment of foreign-origin uranium for domestic end use so as to "assure the maintenance of a viable domestic uranium industry."

In *Count II*, the suit sought a declaration that the USEC is null and void and an order prohibiting DOE from adopting a generic enrichment contract without compliance with the Administrative Procedures Act.

Count III sought to require DOE to allow customers to vary their tails assays at no charge, because the surcharge for the variable tails assay option (VTAO) under the USEC tends to reduce uranium consumption.

Count IV sought to prohibit the use of the federal government stockpile, either through sales of pre-production inventories or through over-feeding the enrichment cascades to save power costs.

Count V sought judicial validation and enforcement of the principle that the US industry shall be capable of supplying 100 percent of US requirements at any time, and under any hypothetical supply disruption.

In September 1985, Judge Carrigan ruled in favor of the producers on Count II of the suit, a decision that DOE immediately appealed. Then, in June 1986, Carrigan ruled on the remaining four counts, deciding in favor of the producers with respect to the all-important Count I. Judge Carrigan's ruling on Count I ordered that pending DOE's completion of a rulemaking, that DOE "shall restrict its enrichment of source or special nuclear materials of foreign origin intended for use in a utilization facility within or under the jurisdiction of the United States" until the viability of the domestic uranium industry is assured. The restriction, effective January 1, 1987, was to be 100 percent. Carrigan's ruling also ordered DOE to commence administrative rulemaking proceedings to establish criteria for providing enrichment services that would comply with the mandate of the Atomic Energy Act.

DOE then appealed the decision on Count I, and the Appeals Court consolidated the two appeals, hearing arguments in September 1986. Counts III, IV, and V, respectively, were not appealed.

The Appeals Court Ruling

On July 20, 1987, a three-judge panel of the US Court of Appeals for the Tenth Circuit unanimously affirmed US District Court Judge James Carrigan's June 1986 order prohibiting the US Department of Energy (DOE) from enriching any non-US-origin uranium for use in a US reactor (Count I). The Appeals Court also remanded (sent back) to Carrigan's jurisdiction the September 1985 ruling declaring the Utility Services Enrichment Contract (USEC) null and void (Count II).

In its ruling, The Appeals Court stated that the language of the statute is unambiguous, and the mandate is clear that DOE "shall" impose such restrictions as are necessary to assure the viability of the domestic uranium industry. The word "shall" in the statute is mandatory, and contrary to DOE's arguments, the additional words of the statute, "to the extent necessary", do not confer on DOE the discretion to decline to impose restrictions based on a DOE contention that restrictions would not be effective in assuring the domestic uranium industry's viability.

"The DOE's interpretation strains the plain meaning of section 2201(v). The unambiguous language of the statute requires the DOE to refuse enrichment of foreign uranium 'to the extent necessary to assure' a viable domestic industry. The DOE may determine how much restriction is required to assure viability, but it cannot decide not to impose restrictions when the industry is not viable. It must continue to impose restrictions until the domestic industry becomes viable."

The Court noted that DOE's argument that a 100-percent restriction would be ineffective in helping the industry does not alter the plain meaning of the statute, saying "The DOE's argument that this policy is not wise in the present uranium market should be made to Congress and not to the courts. We can only apply the statute as Congress passed it." Finally, the Court relied to a considerable extent on the legislative history surrounding the enactment of the statute.

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and as evidenced by contemporaneous statements in Congress, that history supports the conclusions of the Tenth Circuit.

On the issue of the USEC (Count II), the Tenth Circuit sent the matter back to Judge Carrigan's court to resolve the question of whether the producers had "standing"; that is, the right to pursue their claims with respect to the USEC. (A party generally has standing if that party can show injury and if the Court can redress that injury by its action.) The central issue was whether the adoption of the USEC by DOE caused a decline in demand for domestic uranium. If it did so, the producers were injured, thereby meeting the test for "standing." But the Court apparently was not convinced that the record reflected sufficient causal connection between the UESC and a decreased demand for domestic uranium so as to say that the producers were injured, and thus remanded that question to Judge Carrigan's court for further findings. Until the standing issue is resolved, the Appeals Court will refrain from issuing any opinion on the merits of the producers' challenge to the USEC.

DOE Petitions to Stay the Appeal

Instead of petitioning the Appeals Court for a rehearing, which many observers believed would not be well received by the Court, on July 23 the Justice Department representing DOE filed an emergency motion in that court to stay the decision pending the filing of a petition for *writ of certiorari*.

In its motion for a stay, DOE set forth arguments as to why the motion should be granted. The arguments were similar to those originally advanced in opposition to Count I, and include:

1. US utilities would be harmed should the court-imposed restrictions be required to go into effect. DOE contended that "the immediate shock of the order in this case falls on utilities that use nuclear fuel." Because many utilities rely on DOE contracts, chiefly the USEC, those utilities may find themselves with "incompatible commitments" for enrichment of their non-US-origin material.

2. DOE's enrichment business would suffer harm. DOE "faces the prospect of losing hundreds of millions of dollars in enrichment sales, as well as the possibility of being held liable to the utilities for their losses." The main thrust of DOE's argument, however, concerned the impact the ruling could have on DOE's future as an enrichment supplier. Having abandoned DOE for foreign enrichment, there would be considerable incentive to continue using those sources of enrichment services in the future.

3. The impact of the ruling on US foreign relations would be harmful, particularly with Canada and Australia. The motion notes that the Department of State and the office of the US Trade Representative had submitted declarations in the case, saying that the District Court order would have "grave consequences" for US trade and diplomatic relations with other countries. Both Canada and Australia had previously sent to the State Department formal notes expressing their countries' concern over the impact of the court order, and both have reiterated their concerns since the Appeals Court decision.

The DOE motion also called attention to the potential effect on US non-proliferation policy, saying the USA's ability to be a "consistent, reliable partner" in international nuclear cooperation is a vital element in US foreign relations. In addition, DOE's position as an enrichment supplier is a key link in maintaining US legal controls over uranium, in order to protect against nuclear proliferation.

4. According to DOE, a stay would not cause further harm to the US production industry. DOE's motion for stay said "because any prospect for recreating a viable domestic uranium industry depends on there being a viable nuclear power industry to consume the producers' product, as well as a viable enrichment services provider in the United States to make that product into a usable nuclear fuel, the ultimate interests of miners and millers will, in fact, be undercut by the order in this case."

At the time of the motion for stay, DOE was continuing to enrich non-US-origin uranium for use in US reactors, asserting that earlier Congressional action essentially gives DOE the right to enrich non-US-origin feed until the matter is finally resolved by the US Supreme Court. DOE gave its basis for this position as language contained in the appropriations bill funding DOE for Fiscal Year 1987, in which the Conference Committee Report described a resolution to the lawsuit as "a decision by the Court of Appeals or the Supreme Court, should *certiorari* be granted." DOE referred to this language as being tatamount to a "legislative stay."

Numerous motions and briefs were filed in the Appeals Court by, and in support of, both sides in the case with respect to the granting of the stay and the effectiveness of the District Court's decision. The states of Colorado, New Mexico, Nevada, Utah, and Wyoming filed amici curiae briefs, opposing DOE's "legislative stay" interpretation. And in a letter to the Tenth Circuit Court of Appeals,

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lawyers for the plaintiffs (the Producers) protested DOE's refusal to comply with the court decision, saying "In effect, the government has given itself a stay of this Court's Order by its self-serving interpretation of legislative action on a continuing appropriations bill."

Appeals Court Grants Stay, DOE Files Writ of Certiorari

In October there were two new developments in the US Producers vs. DOE lawsuit:

1. The Tenth Circuit Court of Appeals granted, until November 7, 1987, DOE's request for a further stay of Judge Carrigan's 1986 order barring the enrichment of non-US-origin feed for use by US utilities.

2. On October 19, DOE filed its petition for a *writ of certiorari* with the Supreme Court. The filing of that petition extended the stay until the Supreme Court should either deny the petition (in which event the case would be remanded to Judge Carrigan, who would be expected to enforce his original order), or the Supreme Court ultimately decides the case after granting the petition for *writ of certiorari*. (The Supreme Court did grant *certiorari* in January 1988, leading to widespread speculation over when the Court might finally rule in the case. As of press time, no such ruling had been made.)

* * *

The US-Canada Free Trade Agreement

On October 4, 1987, President Reagan announced his intention to enter into a trade agreement with Canada on January 3, 1988. With respect to uranium, the agreement (as presently structured) provides:

1. That Canadian-origin uranium be exempt from any restrictions on enrichment, beginning January 1, 1989. This essentially negates Section 161(v) of the Atomic Energy Act as it pertains to Canadian uranium;

2. That the uranium upgrading requirements of Canada's Atomic Energy Control Act will be eliminated with respect to uranium exported to the USA;

3. That both countries prohibit restrictions on imports or exports of uranium from the other country, including quantitative restrictions, taxes and minimum import or export prices.

If the Free Trade Agreement (FTA) were adopted with these provisions, Canadian-origin uranium would be considered to be the same as US-origin uranium for purposes of import into the USA, a situation effectively mooting both the on-going US Producers vs. DOE lawsuit and the import-limitation portion of the Senate Energy Committee's proposed legislation.

In the months following the announcement of the FTA, many uranium buyers in the USA felt that the need to buy US-origin uranium had again greatly diminished, and that even a Supreme Court decision favorable to the US Producers might not have much affect on procurement decisions with regard to origin of material. The US producers, on the other hand, immediately began exploring every possible avenue either to exempt uranium from the FTA's provisions, or to try to prevent passage of the FTA in the US Congress. By the end of the year, the FTA's eventual passage was in considerable doubt.

* * *

EIA Viability Determination

In November, the US Energy Information Administration (EIA) released its annual report entitled *Domestic Uranium Mining and Milling Industry: 1986 Viability Assessment*. The purpose of the study is to provide the Secretary of Energy with the information needed to make an annual determination of the industry's viability, as required under a 1983 amendment to the Atomic Energy Act of 1954. The 1986 assessment indicated that the industry had not recovered significantly from the previous year (in which it was deemed non-viable) despite somewhat increased production.

Status of the Industry in 1986

1. US uranium production in 1986 totaled 13.5 million pounds U_3O_8, up 19 percent from the 1985 level of 11.3 million pounds, which was the lowest since 1956. The number of sources contributing to production dropped from 50 in 1984, to 41 in 1985, to 35 in 1986.

2. During the years 1983 to 1986, the domestic uranium industry lost a total of $766 million, including a 1985 total of $419 million. In 1986, the industry's net deficit improved, to $42 million. However, total industry assets, including both current and non-current assets as well as property, plant and equipment (PP&E) declined steadily, dropping from approximately $3,558 million in 1982 to

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approximately $1,771 million in 1986).

3. Exploration expenditures in 1986 increased slightly to $22.1 million, after having fallen from $27.4 million in 1984 to $20.6 million in 1985. Drilling activity, the primary indicator of exploration effort, increased from 1.8 million feet in 1985 to 2.1 million feet in 1986.

4. Overall uranium industry employment in 1986 dropped to a low of 2,100 person-years, a 13-percent decline from 1985 and a 77-percent decline from 1982. Employment specifically in uranium mining was about 22-percent lower than in 1985, while employment in milling remained approximately the same as the previous year.

5. The production costs of most US uranium producers remain above recent contract prices.

Import Commitment Dependency — For 1986, the EIA study showed that the US utilities as a group used somewhat more imported uranium as a percentage of their requirements than in most previous years. Imports accounted for about 44 percent of domestic utility requirements in 1986. (Imports represented 52 percent of US requirements in 1982, 26 percent in 1983, 39 percent in 1984, and 34 percent in 1985.) According to the study's projections for future years, "annual imports of natural and enriched uranium for the reference case are about 30 percent of requirements in 1987, increase to above 50 percent in 1991, and reach a peak of about 64 percent in 1998."

Following the publication of the EIA study, Secretary Herrington declared the US uranium industry non-viable for calendar year 1986. This finding made the third consecutive year that the industry has been deemed non-viable.

* * *

The Price Anderson Act

During the first part of 1987, considerable lobbying and legislative activity focused on renewal of the Price Anderson Act, the legislation that sets an upper limit on off-site nuclear accident liability, and which was due to expire August 1, 1987. Influenced by the accident at Chernobyl, efforts to keep the Act's existing total liability ceiling of approximately $700 million gave way to the realization that much increased coverage was needed. Various versions of renewal legislation that were drawn up in the House and Senate all ended up with new liability limits in the range of $5 to $7 billion. In June, a General Accounting Office report estimated that a limit of $6 billion would cover off-site damages at 95 percent of US reactors (113 of the 119 reactors considered), and the report endorsed renewal of the Act. However, the Price Anderson Act was allowed to lapse without renewal. In the short-term, the Act's expiration mainly affected contractors to DOE, whose liability coverage ceased, rather than reactor licensees, which continued to be covered under the old limits.

During the second half of 1987, several bills to renew the Act were developed in the House and Senate, but support for passage was lacking. In July, the House passed a bill calling for limits of $63 million per reactor per accident, in aggregate totaling about $7 billion, and a contractor liability of $7 billion. In the Senate, the Energy and Natural Resources Committee, which oversees DOE, approved a bill setting an aggragate liability limit of $6 billion. Separately, the Senate Environment and Public Works Committee, which oversees the NRC, approved a bill calling for a limit of $60 million per reactor, or a total limit of about $6.7 billion. The two Senate commitees, however, were unable to resolve their differences and combine the respective bills into a package that could be taken to the Senate for a vote by the end of the year.

Although there were fears that contractors doing nuclear-related work for DOE would simply refuse to sign any new contracts without the coverage provided by the Price-Anderson Act, this proved not to be the case. Nearly all of the major contractors renewed their contracts, or signed new ones, using provisions of an existing law (P.L. 85-804) to gain liability coverage.

* * *

Ban on South African Uranium Imports

Throughout 1987, restrictions on uranium imports from South Africa and Namibia into the USA (under the Comprehensive Anti-Apartheid Act of 1986) continued to be subjected to various interpretations and legal challenges. During the first half of the year, an interim interpretation by the Treasury Department banned import into the USA of southern African uranium in any form, except so-called "transient" imports intended for processing and subsequent re-shipment to other countries.

On July 2, the Treasury Department issued its "final" interpretation, which differed markedly from the interim one. While the new interpretation continued to ban the

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import of uranium "ore or oxide" (the wording used in the Anti-Apartheid Act), it allowed uranium in the form of UF_6 to be imported, reasoning that such material had been "substantially transformed" and was, therefore, not subject to restriction. The new interpretation also stopped transient imports of U_3O_8, although such imports of natural and enriched UF_6 were not affected. In September, the NRC issued a policy statement that conformed closely with the Treasury Department's interpretation — the NRC then reexamined and modified several existing licenses to import uranium, as well as other pending licenses, to conform to its interpretation.

In response to what some critics saw as a blatant loophole in the legislation, a group composed of several interest groups as well as some members of Congress filed suit in federal court, requesting an emergency stay of the NRC regulations, that would block the import of any UF_6 (natural or enriched) from southern Africa. The court rejected the emergency motion, but allowed the suit to proceed under a normal schedule. The issue of a "loophole" involving UF_6 prompted some action in Congress after the NRC interpretation was announced. There were discussions aimed at including UF_6 in the provisions of the Anti-Apartheid Act, possibly allowing transient imports of southern African material, as well as possibly exempting Namibia from the Anti-Apartheid legislation. However, by the end of the year, no other actions had been taken with regard to changing the rules on southern African uranium imports.

* * *

Changes in DOE's High-Level Waste Program

In late January 1987, DOE sent to Congress a proposal that officially postponed the date on which DOE expected to be able to receive high-level waste materials into the first repository specified under the Nuclear Waste Policy Act of 1982 (NWPA). The proposal also postponed the date expected for opening of a Monitored Retreivable Storage (MRS) facility, assuming one would be authorized by Congress, and it reaffirmed the indefinite postponement of the siting process for the second repository specified under the NWPA. Postponing the completion date of the first repository set back the timetable to 2003, five years later than the 1998 date originally mandated under the NWPA. The shift in schedule for the MRS, which had not yet been officially authorized by Congress, delayed for two years the expected date for taking spent fuel, to 1998.

The postponements were not a surprise, and critics of DOE's handling of the repository program used the occasion to question again the legality and political neutrality behind DOE's making such plans without Congressional authorization. Given the many legal obstacles blocking DOE's efforts to find potential sites for the repository, and the intense controversy generated by nearly every step of the process, DOE's ability to complete a repository by the mandated time had for some time been seriously questioned.

Throughout most of 1987, following DOE's January announcement, the high-level waste program appeared to be at a near-standstill politically, even though site characterization activities contined at the three sites that had been chosen as finalists for the repository — Yucca Mountain, Nevada; Deaf Smith County, Texas; and Hanford, Washington. It was clear that in Congress, confidence in the program was diminishing, and several key Congressmen had expressed serious doubts that without major restructuring, the program would never accomplish its goal.

Finally, in December 1987, members of key committees of the US House of Representatives and Senate agreed on a compromise package of amendments to the Nuclear Waste Policy Act (NWPA) that creates major changes in the high-level waste disposal program. President Reagan signed the bill on December 22, 1987.

The compromise, which was part of the FY1988 budget reconciliation bill, focused DOE's efforts on the Yucca Mountain site, and directed DOE to cease site characterization work at the remaining two candidate sites — Hanford, Washington and Deaf Smith County, Texas. In the event that the Yucca Mountain site proves unsuitable, DOE is to cease work there and report its findings back to Congress.

In addition, the bill authorized construction of a Monitored Retrievable Storage (MRS) facility, but with conditions that make it impossible for an MRS to assume the role of a de facto waste repository. Authorization for construction of the MRS will only take place after the Nuclear Regulatory Commission (NRC) licenses the permanent repository, preventing the MRS from acting as a substitute for a permanent facility.

The compromise in Congress created both antagonism and pessimism in Nevada. Some Nevada officials believe that the state has sufficient evidence to prove the site unsuitable, but fear that political pressure from Washington, D.C. will force DOE to arrive at a conclusion of suitability regardless of the "facts."

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One of the most contentious issues involves interpretation of the Site Characterization, a massive effort to document the physical conditions of the repository, which is designed to provide the information for a determination of suitability or non-suitability. In January, DOE released a "consultation draft" of the Site Characterization Plan (SCP), summarizing the 7,000-plus pages of the actual document. A prime concern of scientists is the rate of ground-water migration through the rocks at the site. The Site Charcterization will focus on obtaining the information to document (or estimate) any potential water flow or other problems.

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1987 US URANIUM PRODUCTION ACTIVITIES

Introduction

The US uranium production industry was fairly stable during 1987, although at rather low production levels. Production from all sources totaled approximately 12.5 million pounds U_3O_8, a decrease of 10 percent from 1986 production of 13.9 million pounds. Changes at three production facilities largely accounted for the drop in output:

1. Cotter Corporation's Schwartzwalder mine in Colorado suspended operations in January;
2. USX Corporation's (formerly U.S. Steel) south Texas solution mining operations changed over from production to restoration in early 1987; and,
3. Production at the Umetco Minerals/Energy Fuels Nuclear White Mesa mill (Figure 35) declined by 400,000 pounds to 4.5 million pounds U_3O_8.

The distribution of production between conventional, by-product and solution mining remained similar to 1986 (Table 31).

Table 31

DISTRIBUTION OF US PRODUCTION BY TYPE*
(Millions of Pounds U_3O_8)

	1982	1983	1984	1985	1986	1987
By-Product	3.2	3.1	3.1	3.6	3.5	3.6
Conventional	20.7	15.3	9.7	5.6	8.8	7.9
Solution Mining	3.0	2.8	2.1	2.1	1.6	1.0
Total	26.9	21.2	14.9	11.3	13.9	12.5

*Nuexco estimates.

Conventional Producers

The Colorado Plateau and the Arizona Strip — Nuexco estimates that the White Mesa uranium mill at Blanding,

Figure 35. Energy Fuels Nuclear's White Mesa uranium mill at Blanding, Utah.

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Utah produced about 4.5 million pounds U_3O_8 in 1987; 3.8 million to the account of **Energy Fuels Nuclear** and its Swiss partners, and 700,000 to the account of **Umetco Minerals Corp.** The mill's 1986 production was 4.9 million pounds. (Table 32 shows the status of conventional uranium mills in the USA.) The mill was designed to produce about 1.6 million pounds U_3O_8 per year, but the availability of higher-grade breccia-pipe ores discovered by Energy Fuels in northern Arizona has permitted an output of almost 5,000,000 pounds per year during the last two years.

Energy Fuels has mined breccia-pipe ores from the Hack Canyon and Pigeon mines on the north side of the Grand Canyon. The Hack Canyon pipes (3 in all) have been mined out and the mine area currently is being reclaimed. A new mine, Kanab North, is ready to begin production for Energy Fuels in 1988. The Pine Nut and Hermit mines are being developed and are expected to start producing in 1990. Development of the Canyon pipe, the first new mine on the south side of the Grand Canyon, has been repeatedly delayed by environmentalist opposition.

Umetco Minerals, a subsidiary of Union Carbide Corporation, has a 70-percent interest in the White Mesa mill but does not have sufficient high-grade reserves to fully utilize its share of the mill's production capability under current market conditions. During 1987, Umetco produced approximately 700,000 pounds of U_3O_8 from ores mined in the Egnar Plains area on the Colorado/Utah border. The White Mesa mill will be closed through mid-1988, while the mi ers build up sufficient stockpiles for an operating run of 8 to 12 months.

Rio Algom Corp. continued to operate its Lisbon, Utah mill, using both company and outside-source ore to produce about 700,000 pounds U_3O_8 in 1987.

Atlas Corporation announced plans to liquidate its uranium assets in order to concentrate efforts on precious metals. The Atlas mill in Moab, Utah was licensed in 1956 and was producing 1.8 million pounds per year as recently as 1982. Atlas' decision to withdraw from uranium follows problems with the NRC in re-licensing the mill. Even after announcing its withdrawal, however, Atlas has continued to press for renewal of its NRC license and that renewal currently is under review by the NRC.

Texas and New Mexico — A joint venture of **Chevron Resources Co.** (60 percent) and **Total Minerals Corp.** (40 percent) has started development at Rhode Ranch. Ore from this shallow deposit will be processed at Chevron's Panna Maria mill, which currently is treating ore from its Mt. Taylor mine. Production from Rhode Ranch is expected to begin in January 1988, at a rate of over one million pounds U_3O_8 per year. This development is particularly notable as the first new US open-pit mine since the late 1970s.

The Rhode Ranch project is 80 miles south of Chevron's Panna Maria mill, which was built to process ore from Chevron's Panna Maria open-pit mine. This mine was placed on standby in June 1985. Uranium deposits at Rhode Ranch average less than 100 feet in depth and are higher grade (over 0.20 percent U_3O_8) than most deposits in the south Texas region. Chevron probably will use most of the Panna Maria mine equipment for mining at Rhode Ranch, and ship the ore produced to Panna Maria by truck.

Chevron acquired the **Mt. Taylor** project near Grants, New Mexico, when it bought Gulf Oil Co. in 1984. Currently, Mt. Taylor produces about 600 tons of ore per day at an average grade of about 0.5 percent U_3O_8, totaling about 1.5 million pounds U_3O_8 per year. During 1987, ore from Mt. Taylor was transported to the Panna Maria mill, a distance of over 900 miles, by rail. It is now being milled at the Homestake mill near Grants. **Homestake Mining Co.** continued to produce some U_3O_8 by conventional methods in the Grants, New Mexico area. At the company's Section 23 mine, a small crew mined small quantities of higher-grade material. Should market conditions allow, the Mt. Taylor mine has the reserves and production capability to at least double its current output.

Colorado — The **Cotter Corporation's** Schwartzwalder mine near Golden, Colorado suspended operation in January 1987. This mine has produced approximately 15 million pounds U_3O_8 during its 35-year operating life. The mine uses a radiometric sorter to reduce waste in the relatively high grade (about 0.30 percent U_3O_8) ore prior to shipping it to Cotter's mill at Canon City, Colorado. Cotter also had some minor production from its Thornberg mine, using a contractor who shipped the ore to Rio Algom's Lisbon mill.

Wyoming — The only open-pit uranium mines that operated in the USA during 1987 were **Pathfinder Mines Corporation's** Shirley Basin and Gas Hills, Wyoming properties. These operations produced somewhat more than 500,000 pounds U_3O_8 in 1987. The Gas Hills mill, which was built in 1958, recently has been refurbished and was operating below capacity processing low-grade stockpiles. The mill was closed for over two years before reactivation

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Table 32

1987 OPERATING STATUS OF CONVENTIONAL URANIUM MILLS IN THE USA

Company	Approximate Operating Schedule or Status	Rated Capacity[1]	Location
Active Mills			
Chevron Resources Co.	Partial	2,500	Hobson, Texas
Cotter Corp.	Suspended (1987)	1,200	Canon City, Colorado
Homestake Mining Co.	Partial	3,400	Grants, New Mexico
Pathfinder Mines	Suspended (1988)	2,800	Gas Hills, Wyoming
Pathfinder Mines	Partial	1,800	Shirley Basin, Wyoming
Rio Algom Corp.	Full	750	La Sal, Utah
Umetco/ Energy Fuels Nuclear	Periodic	2,000	Blanding, Utah
Umetco (Union Carbide)	Heap Leaching	1,400	Gas Hills, Wyoming
Inactive Mills[2]			
American Nuclear Corp.	Inactive	950	Gas Hills, Wyoming
Anaconda (ARCO)	Inactive[3]	6,000	Grants, New Mexico
Atlas Minerals	Inactive	1,400	Moab, Utah
Bear Creek Uranium	Dismantled	2,000	Powder River Basin, Wyoming
Bokum Resources Corp.	Incomplete	2,000	Marquez, New Mexico
Conoco/Pioneer	Dismantled	3,400	Falls City, Texas
Dawn Mining Company	Inactive	450	Ford, Washington
Exxon Minerals Company	Dismantled	3,200	Powder River Basin, Wyoming
Quivira Corp. (Kerr-McGee)	Inactive	7,000	Grants, New Mexico
Minerals Exploration Company	Inactive	3,000	Red Desert, Wyoming
Petrotomics Company	Dismantled	1,500	Shirley Basin, Wyoming
Plateau Resources Ltd.	Inactive	1,000	Ticaboo, Utah
Sohio Western Mining	Dismantled	1,600	Cebolleta, New Mexico
Umetco (Union Carbide)	Inactive	1,300	Uravan, Colorado
UNC Resources	Inactive[4]	3,000	Church Rock, New Mexico
Western Nuclear Inc.	Inactive	1,700	Jeffrey City, Wyoming
Western Nuclear Inc.	Inactive	2,000	Wellpinit, Washington

[1]Capacity in tons of ore per day (tpd).
[2]Mill inactive throughout 1987.
[3]Decommissioning expected to begin in 1988.
[4]Decommissioning plan currently under review by the NRC.

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in July 1987. Mining operations also were suspended during that period. An indefinite shutdown of the mine and mill was announced in March 1988.

Current plans at Shirley Basin may include a short shutdown of the mill in the near future so that waste stripping can uncover more ore, followed by a gradual increase back to an annual production level of about 12 million tons of waste, 220,000 tons of ore and 750,000 pounds of U_3O_8.

Solution Mining

In 1987, US uranium production from solution mining declined to less than one million pounds U_3O_8 for the first time since 1975. Both **USX Corp**. and **Everest Minerals Corp.** moved from active production to restoration at previously high-output production centers. A number of recent developments, however, could result in a significant increase in future production from solution mining. Table 33 shows the status of solution mining projects in the USA.

Texas and New Mexico — The Clay West project began operation in 1975 as the largest uranium solution mining project built to that date, with an initial capacity of 250,000 pounds U_3O_8 per year. The project is owned by **USX Corp.**, (50 percent, operator) and **Niagara Mohawk Power Corp**. (50 percent). Production over the past several years from the Clay West project has been in the range of 500,000 to 800,000 pounds per year; but 1987 production is estimated to be approximately 100,000 pounds U_3O_8, as much of the changeover from production to restoration was made in early 1987. USX's wholly-owned and adjoining project, Burns Ranch, was shut down in July 1986.

Everest Minerals' Mt. Lucas project changed over to restoration in late 1987, after averaging about 500,000 pounds per year since 1984. In December 1987, Everest started up the Tex-1 project which, in combination with the nearby satellite Gruy project (expected to start up in 1988), is scheduled to produce 500,000 pounds U_3O_8 per year through Everest's Hobson recovery facility.

Malapai Resources Co. bought the Holiday/El Mesquite and O'Hern properties in south Texas from Mobil Oil in late 1987. Under Mobil's management, these properties produced about 500,000 pounds in 1981, but smaller quantities more recently.

Uranium Resources, Inc. (URI) prepared its Kingsville Dome and Rosita projects to begin production in 1988, at rates of 800,000 pounds and 500,000 pounds U_3O_8 per year, respectively. URI also is preparing a solution mining permit application for its Churchrock, New Mexico project, near a conventional underground mine formerly operated by United Nuclear Corp.

Total Minerals Corp. acquired the West Cole project from Tenneco Minerals in 1987. This project is located in Webb County, Texas and was placed on standby by Tenneco in 1984. Total reactivated the facility in 1987 and expects to produce 200,000 pounds U_3O_8 per year by 1990.

Intercontinental Energy Corp. (IEC) increased production at its Lamprecht facility to almost 100,000 pounds in 1987. In December 1987, Greenwood Holdings, Inc. (GHI) purchased IEC, distributing all of IEC's oil-related assets and liabilities to GHI, leaving IEC with only uranium-related interests. Following that move, a newly-formed IEC Employee Stock Ownership Trust and a group of US and European investors purchased all of IEC's outstanding capital stock.

Wyoming and Nebraska — **Everest Minerals** expects to begin production at its Highland, Wyoming project in January 1988, at a projected rate of 800,000 pounds U_3O_8 per year. **Malapai Resources** acquired the Irigary, Wyoming project from Westinghouse, and restarted the plant in late 1987. Malapai forecasts 1988 production from Irigary at 250,000 pounds U_3O_8. Malapai also has plans to start production at its Christensen Ranch, Wyoming property in 1989.

In the longer term, **Ferret Exploration Company's** Crow Butte, Nebraska project is expected to be capable of producing up to 1 million pounds per year in the early 1990s. Ferret has submitted an application for full commercial production, and initial production at a rate of 500,000 pounds U_3O_8 per year is expected in 1989.

By-Product Production

By-product uranium production in the USA is dominated by **International Minerals and Chemical Corp.** (IMC) and **Freeport Uranium Recovery Company**, which produce about 1.9 million and 1.2 million pounds per year, respectively. Both producers extract uranium from phosphoric acid, derived from the processing of phosphate rock. Uranium-producing phosphoric acid production facilities are summarized in Table 34 .

By-product uranium also has been produced in the USA from coal, copper, beryllium and rare earth recovery facilities. Currently, **Rhone Poulenc** recovers about 30,000 pounds U_3O_8 per year from the processing of rare earth

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Table 33

CURRENT STATUS OF SOLUTION MINING PROJECTS IN THE USA

Location	Company	Mine Site	Current Status
Nebraska	Ferret Exploration Co.	Crow Butte	Permitting
		Big Red	Exploring
New Mexico	Mobil Oil Corp.	Crown Point	Undeveloped
	Uranium Resources, Inc.	Church Rock	Permitting
Texas	Caithness Mining Corp.	McBride	Restored
	Chevron Resources Corp.	Palangana	In Restoration
	Conoco, Inc.	Trevino	Restored
	Everest Exploration, Inc.	Hobson-1	Restored
		Hobson Tex-1	Operating
		Las Palmas	In Restoration
		Mt. Lucas	In Restoration
		Gruy-7B	Permitting
	Intercontinental Energy Corp.	Pawnee	In Restoration
		Zamzow	In Restoration
		Lamprecht	Operating
	Malapai Resources Co.	El Mesquite	Operating
		Holiday	Operating
		O'Hern	Operating
	Total Energy Resources	West Cole	Operating
	USX, Inc.	Boots/Brown	In Restoration
		Burns/Moser	In Restoration
		Clay West	In Restoration
		Pawlik	In Restoration
	Uranium Resources, Inc.	Benavides	In Restoration
		Kingsville Dome	Under Development
		Longoria	Restored
		Rosita	Permitting
	Westinghouse Electric Corp.	Bruni	In Restoration
Wyoming	Malapai Resources Co.	Irigaray	Operating
		Christensen Ranch	Permitting
	Everest Minerals Corp.	Highland	Under Development
	Sequoyah Fuels Corp.	Bill Smith	Pilot Plant Operating
	Ogle Petroleum Corp.	Bison Basin	In Restoration[1]
	Uranerz USA	Ruth	Undeveloped
	CEB Co.	Leuenberger	Undeveloped

[1]Being restored by Altair Resources after default by Ogle.

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oxides at its plant in Freeport, Texas, and **Energy Fuels** produces U_3O_8 as a by-product of copper at its plant at Bingham Canyon, Utah. The Energy Fuels' operation extracts about 10,000 pounds U_3O_8 per month. **Brush Wellman, Inc.**, which produced a few thousand pounds per year from its beryllium operation in Utah, decommissioned its uranium production circuit in 1987. The uranium from copper processing facility at Anamax's inactive Twin Buttes mine was sold to **Cyprus Minerals**, which operates the nearby Bagdad copper mine. Cyprus has not announced any plans to install or operate that facility.

Several mines in the Grants, New Mexico district produce by-product uranium by treating the mine water pumped from uranium mines. **Homestake Mining Co.** and **Quivira Mining Co.** currently recover a total of about 400,000 pounds U_3O_8 per year from mine waters in conventional underground mines, most of which are no longer in operation.

Table 34

URANIUM BY-PRODUCT FROM PHOSPHORIC ACID PRODUCTION

Production Facility	Phosphoric Acid Producer	Uranium Producer	Nominal Capacity (lbs U_3O_8/yr)	Current Status	Comments
New Wales, FL	IMC	IMC	1,200,000	Operating	Opened in 1980
Plant City, FL	CF Industries	IMC	700,000	Operating	Opened in 1980
Bartow, FL	CF Industries	IMC	500,000	Standby	Closed in July 1985
Uncle Sam, LA	Freeport	Freeport	800,000	Operating	Opened in 1978
Donaldsonville, LA	Agrico Chem. Co.	Freeport	450,000	Operating	Opened in 1981
Bartow, FL	Farmland Industries, Inc.	UG USA, Inc.	400,000	Standby	Purchased from Westinghouse in 1985. Last operated in Sept. 1981.
Tampa, FL	Gardinier, Inc.	Gardinier, Inc.	425,000	Mothballed	Closed in March 1982
Mulberry, FL	W. R. Grace & Co.	UNC Resources, Inc.	300,000	Renovation*	Closed in 1980.
Calgary, Alberta	Western Coop. Fertilizers, Ltd.	Earth Sciences Inc.	120,000	Standby	Closed in August 1987
TOTAL			4,895,000		

*Currently being renovated to treat industrial waste for the recovery of strategic metals, including uranium.

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Table 35

1987 US URANIUM INDUSTRY EVENTS

Month	Organization	Event or Announcement
January	Cotter Corp.	Announced plans to suspend production operations at Canon City, Colorado mill and the Schwartzwalder mine, effective January 30, 1987.
February	Energy Fuels Nuclear, Inc.	Restarted Bingham Canyon, Utah by-product copper facility acquired from Westinghouse.
March	Umetco Minerals Co.	Resumed mining operations at two mines in the Uravan, Colorado area.
April	Umetco Minerals Co.	Resumed heap leaching of low-grade stockpiles at Gas Hills, Wyoming mine.
May	Chevron Resources Co.	Exercised option to acquire Rhode Ranch property in Texas, with Minatome (now Total Mineral Resources) (45%).
June	Malapai Resources Co.	Restarted production at the Irigaray solution mining project in Wyoming.
	Pathfinder Mines Corp.	Announced startup of refurbished Lucky Mc mill in Wyoming, after a two-year shutdown.
July	US Tenth Circuit Court of Appeals	A three-judge panel unanimously affirmed Carrigan's June 1986 ruling in the US Producers vs. DOE lawsuit. DOE filed emergency motion to stay the decision pending filing for *writ of certiorari* to the US Supreme Court.
August	Atlas Corp.	NRC ordered Atlas to close Moab, Utah mill because of disagreement on financing of decommissioning.
	Earth Sciences	Operations suspended at Calgary, Alberta by-product phosphoric acid plant.
	USX Corp.	Ceased production at Clay West solution mining project in Texas.
	Malapai Resources Co.	Restarted production at Irigaray solution mining project in Texas.
	Total Minerals Corp.	Restarted solution mining operations at West Cole project acquired from Tenneco Minerals.
September	Atlas Corp.	Announced closure and write-down of all uranium operations.

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Table 35

1987 US URANIUM INDUSTRY EVENTS (continued)

Month	Organization	Event or Announcement
September	Malapai Resources Co.	Acquired Holiday/O'Hern and El Mesquite solution mining properties in Texas from Mobil Oil Corporation.
October	Appeals Court, DOE	Appeals Court granted DOE's request for stay of earlier decision. DOE filed petition to Supreme Court for *writ of certiorari*.
	US-Canada Free Trade Agreement	President Reagan and Prime Minister Mulroney announced their intention to enter into a Free Trade Agreement between the USA and Canada.
November	DOE	Energy Secretary Herrington declared US uranium industry not viable for calendar year 1986.
December	Everest Minerals Corp.	Began production at Tex-1 satellite to Hobson, and shut down Mt. Lucas project, both solution mining projects in Texas.
	Ferret Exploration Co.	Submitted applications to NRC and Nebraska Department of Environmental Control for commercial operations at Crow Butte.
	Intercontinental Energy Corp.	Announced restructuring in which uranium operations are spun off to a newly-formed investor group headed by Lee Erdahl, former president of Ranchers Exploration.
	Rio Algom Corp.	Announced that operations at Lisbon, Utah site would be placed on a "day-to-day" basis due to poor market conditions.
	U.S. Energy	Announced that applications had been filed with the Wyoming Dept. of Environmental Quality for mining permit at Green Mountain project.
	Uranium Resources Inc.	Announced restructuring into URI, a publically-held company traded on the Vancouver Exchange.

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